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ABSTRACT

A project was conducted to analyze, design, develop, implement, and evaluate an instructional unit intended to improve the diagnostic skills of operating personnel in responding to abnormal and emergency conditions at the High Flux Beam Reactor at Brookhaven National Laboratory. Research was conducted on the occurrence of emergencies at similar plants, and existing instructional materials were obtained. An instructional unit for classroom training was designed using the instructional system design approach. The unit is organized in modules, each of which focuses on a task. Performance objectives, enabling objectives keyed to criterion-referenced measure, handouts, charts, tests, and answers to tests were prepared. The methods used may be useful to others who operate high-risk facilities and conduct emergency procedures training. (Extensive appendices contain the job task analysis, learning objectives, cognitive objectives and test items, class schedule, flipcharts, lesson plan, problem scenarios, question pool, lecture critique, supervisor examination, and a brief bibliography.) (KC)

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THE SCHOOL OF MEDIA AND ARTS

of

NEW YORK INSTITUTE OF TECHNOLOGY

announces the

Final Examination

of

Ronald Reyer

for the degree of

MASTER OF SCIENCE

in

TRAINING AND LEARNING TECHNOLOGY

Emergency Procedure Training for Reactor Operators at the High Flux Beam Reactor for Brookhaven National Laboratory

Abstract

This thesis/project describes the analysis, design, development, implementation, and evaluation of an instructional unit designed to improve the diagnostic skills of operating personnel in responding to abnormal and emergency conditions at the High Flux Beam Reactor. Reactor Operating personnel are required, by regulation, to maintain their proficiency in carrying out the plant's emergency procedures on an annual basis. This requirement is accomplished by conducting classroom training and in-plant drills since the plant does not have a simulator. This instructional unit for classroom training was designed using the instructional system design process. The methods used may be useful to others who operate high risk facilities and conduct emergency procedures training.

Thursday, April 26, 1990 at 9:00 a.m.

in

Conference Room, French Chateau
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EMERGENCY PROCEDURE TRAINING FOR REACTOR OPERATORS AT THE HIGH FLUX BEAM REACTOR FOR BROOKHAVEN NATIONAL LABORATORY

a

THESIS/PROJECT

by

RONALD REYER

submitted to the faculty of the
School of Media and Arts

of

NEW YORK INSTITUTE OF TECHNOLOGY

in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

in

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A Thesis/Project

submitted to The Faculty of the

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CHAPTER 1

INTRODUCTION

Overview

This instructional unit was developed to improve the diagnostic skills of operating personnel in responding to abnormal and emergency conditions at the High Flux Beam Reactor. The High Flux Beam Reactor Training Plan requires classroom training annually in the use of the plant emergency procedures. Training in unusual events and diagnostic training is also required to improve the cognitive skills of the certified operating staff in responding to these events. In addition to classroom training, in-plant drills and plant walkarounds are conducted with shifts and individuals to maintain their proficiency in responding to normal and abnormal plant occurrences.

This instructional unit uses actual plant occurrences for discussion of how events were handled using the plant procedures. Paper simulations are presented for reactor operators to do case studies in how they would handle these situations.

Background

After World War II, in the United States hope, was high that exploration of the nuclear sciences would unlock more secrets of the universe as well as lead to peaceful applications of atomic energy. To do this, powerful expensive machines such as nuclear reactors were required at costs well beyond the means of individual institutions. Up to this point, financial support of scientific research by the federal government had been relatively small and selective. In a 1945 report for the federal government on a "Program for Postwar Scientific Research" Vanevar Bush, director of the Office of Scientific Research and Development, wrote "the federal government should accept new responsibilities for promoting the creation of new scientific knowledge and development of new scientific talent in our youth." Thus, in this climate, was Brookhaven National Laboratory (BNL) born, one of the national laboratories created to pursue these objectives, with the financial support of the federal government and its blessing to operate independently.

Brookhaven's mission was to support research in nuclear science and related fields, performed with unique, large-scale research tools. It was to embrace both fundamental and applied science as well as applications to engineering, biology, chemistry and other fields. Its staff of scientists was to represent many disciplines, and active participation by scientists from universities, industry and other laboratories was anticipated. It was to be a cooperative enterprise in the national interest.

To organize this laboratory, 9 leading northeastern universities came together in an association known as Associated Universities, Inc. They formed a non-profit education corporation to manage the laboratory. Its officers were appointed by a board of trustees.

The 9 universities represented on the Board and that still serve, are Columbia, Cornell, Harvard, Johns Hopkins, Massachusetts Institute of Technology, University of Pennsylvania, Princeton, University of Rochester, and Yale.

During the preceding years many of Brookhaven's complex research machines came into existence. The world's first reactor specifically designed for peacetime research purposes, the Brookhaven Graphite Research Reactor (BGRR), began operation in 1950. In 1965, it was succeeded by the High Flux Beam Reactor (HFBR), which continues to be the leading U.S. reactor for research involving external neutron beams. In 1953 the Cosmotron, one of Brookhaven's first accelerators, went into operation. It was a proton accelerator and was the first accelerator in the world to produce particles at energies in the billion electron volt region.

Larger machines were needed and in 1960 the Alternating Gradient Synchrotron (AGS) went into operation. This machine accelerated protons to 33 billion electron volts. Two discoveries made at the AGS - CP violation and the J-particle captured the Nobel prize in Physics. Other important particles found there include the muon-neutrino and the omega-minus.

More recently, in 1982, the National Synchrotron Light Source (NSLS) went into operation. The NSLS provides intense beams of X-rays and vacuum ultraviolet light for research in physics, chemistry, biology and various technologies. In addition, the combination of the NSLS and the HFBR has made Brookhaven a world center for material science research. Today BNL's charter is to support national programs in scientific research and education by:

1. Developing, acquiring, operating and maintaining at the state of the art the large-scale research tools and other specialized facilities and laboratories that best serve academia, industry, and the government in an open "national laboratory" setting.
2. Promoting the productive use of these facilities by scientists from all fields without regard to affiliation.
3. Assisting the government in the solution of problems and the performance of tasks for which available personnel and facilities are appropriate.

The High Flux Beam Reactor was built in 1965 and operated for 16 years at its design power of 40 MW providing a neutron flux of 1.6×10^{15} n/cm^2-sec. This flux was a factor of 50 percent higher than the BGRR. In 1982, modifications were made to increase the reactor power to 60 MW which provided an additional increase of about 50 percent.

In the HFBR, the neutron flux reaches its maximum outside the reactor core where it is readily available for experiments. The neutron beams come to experimenters through beam ports. Since most experiments are run until the number of counts measured is sufficient to give the desired statistical precision, the greater neutron flux cuts by a third the time needed to do experiments.

The HFBR has provided neutrons for an abundance of scientific experiments. Outstanding research in solid state physics has included pioneering studies of solids exhibiting structured distortions, work that led to a more complete understanding of the microscopic interactions in solids. Experimental work in nuclear physics has revealed the first examples of three dynamical symmetries in atomic nuclei, thus opening up an entirely new approach to nuclear structure.

Over the years neutrons, have been used to probe the static and dynamic properties of solids and liquids, as well as the macromolecules that form the building blocks of living systems. Just to cite a few examples, neutrons are a prime source of information on how monoatomic gas (made of one atom molecules) films form on solid surfaces, how charge density is distributed in crystalline solids to create the bonds that hold atoms together, how hydrogen atoms diffuse into certain metals and how metal atoms are integrating into the structure of organic molecules.

Neutron diffraction and scattering techniques today are being used in the life sciences, to determine such things as structures of membranes, ribosomes and proteins, to locate the positions of hydrogen atoms in proteins such as myoglobin and trypsin, and to pinpoint those hydrogen atoms involved in catalysis mediated by trypsin-like enzymes. Also scattering techniques are being used to determine the structure of material that exhibit superconductivity at high temperature.

The Reactor Division operates and maintains the HFBR for scientists to conduct their experiments. After the Three Mile Island accident the Department of Energy (DOE) required that each DOE Category A reactor develop comprehensive training programs for reactor operators and shift supervisors as well as other positions such as radiological protection technicians, maintenance technicians, instrument technicians and responsible technical staff. Category A reactors were defined as those reactors greater than 20 MW in power that could cause a hazard to the public and or the people at the site under certain low probability accident conditions unless mitigated by plant design or operator action.

The HFBR is operated on a 24 hour basis seven days a week. It runs at 60 MW power for three weeks and then is shut down for 2 to 3 days for refueling. The reactor operator positions, starts up, operates, shuts down and refuels the reactor. Normally a shift crew works an eight hour shift and is composed of two reactor operators and a shift supervisor. There are five shift crews including the relief or day crew. There are a total of 25 certified operators and supervisors. The certified supervisor positions include the plant manager, operations group leader, assistant operations group leader, and special projects coordinator.

The training conducted at the High Flux Beam Reactor is done in accordance with a training plan which has been approved by the Department of Energy. This training plan specifies the program/curriculum required for certification of operating personnel. Curriculum for the retraining program is also specified by this plan. Programs for training and retraining of operators are developed by the training group. The training group consists of

a training group leader, two training assistants, a procedures manager and a secretary. This training organization is small compared to organizations at power reactors. A comparable size training organization at a 180 MW nuclear power plant has 26 people in their training organization. This year DOE has passed an accreditation order that will require performance based training programs using instruction system design methods be developed for all critical positions at the HFBR. The training group is planning to increase its staff to about 15 people over the next four years to be able to accomplish this task.

Annual training in both classroom and in-plant drills on emergency procedures is required for a target population of 22 people at the High Flux Beam Reactor. These are the certified operators and supervisors who run the facility. This training is required annually in order to maintain their proficiency to be ready to handle situations that rarely occur. This training is similar to the training pilots receive on flight simulators. It is necessary to assure that proper responses are made during emergency events such that both the plant and public are protected from the potential hazards of melting the fuel and/or releasing radiation to the environment. This training is also required for the operators and supervisors to maintain their certification requirements.

The group characteristics include high school and college graduates with some having previous experience in nuclear technology (Naval Reactors). They all must have passed a classroom reactor fundamentals and radiological protection program, had participated in an "on the job" training program at the reactor and passed written, oral, and demonstrative examinations for certification as a reactor operator and/or supervisor. In addition, the group had from 2 to 25 years operating experience with the average person having about 9 years of experience on the job.

Previous annual classroom instruction given for emergency procedures was presented by reviewing the emergency procedures step by step with the instructor presenting the reasons for each step. This training was then followed by a written examination.

The reactor division head, the operations group leader, the assistant group leader and a number of operators were interviewed to determine the training needs for this instructional unit. The reactor division head stressed the need to conduct training which would test the operators' responses during emergency conditions. The assistant operations group leader stated that the training should stress occurrences that have caused reactor scrams and shutdowns over the past 15 years rather than concentrate on emergencies that have a small probability of occurring. The operations group leader suggested that the classroom training should center on giving emergency situations for small groups to solve using the emergency procedures. Also a number of operators indicated that they would like to discuss situations rather than review the emergency procedures step by step.

Statement of the Problem

Reactor supervisors and operators are required, by regulation, to maintain their proficiency in carrying out the plant's emergency procedures on an annual basis. This requirement is accomplished by conducting classroom training and in-plant drills and walkarounds since the plant does not have a simulator. This training must be done and evaluated annually to assure that both the plant and public are protected from events where operator actions are necessary to place the facility in a safe shutdown condition.

Purpose of the Project

The purpose of this project was to improve the annual training of operator and supervisors in performing the plant's emergency procedures. This instructional unit uses actual plant occurrences for discussion and the development of problem scenarios to improve operator diagnostic skills when using these procedures. Discussions also include events of a lesser probability but that could lead to core damage. Plant occurrences such as loss of cold neutron facility, power failures, primary system leaks, personnel errors, electric equipment failures, pump failures, instrumentation failures, primary system vibration, secondary cooling system leaks, fuel cladding leaks and other miscellaneous failures are discussed. The program accomplished a number of goals as follows:

1. Increased the cognitive knowledge of the operating staff on those events that have caused scrams and shutdowns over the life of the plant and the manner in which they were handled.
2. Increased the cognitive knowledge of the operating staff on the emergency procedures by keying them to actual plant occurrences.
3. Improved the diagnostic skills of the operating crews by having them solve problem scenarios of actual plant occurrences using the plant procedures.

Definition of Terms

Research Reactor - Reactors that produce neutrons used for research in studying matter on the nuclear, atomic and molecular levels.

High Flux Beam Reactor - A research reactor providing a total neutron flux of 2.4×10^{15} neutrons/cm^2 - Sec at a power of 60 megawatts.

Emergency Procedures - Procedures used to place the reactor in a safe shutdown condition following abnormal or accident conditions.

Scram - Rapid insertion of reactor control rods to shutdown the reactor.

Shutdown - Reactor is subcritical and cooled.

Operator - Person operating reactor controls, manning rural route and performing refueling.

Shift Supervisor - Responsible for all activities carried out at the reactor during the shift.

Cold Neutron Facility - Provides intense beams of very low energy neutrons by the use of a liquid hydrogen moderator system.

Primary System - Heavy water cooling system used to remove the fission heat from the fuel elements in the reactor core.

Secondary Cooling System - Light water cooling system used to remove the heat from the primary cooling system and discharge the heat to the atmosphere through the use of cooling towers.

Plant Walkaround - Observation of the performance of a normal or emergency procedure by supervision with the operator simulating the procedure to be performed.

Fuel - U-235 fuel used in the reactor core.

Fuel Cladding - Encasement around U-235 fuel to act as a barrier to fission products escaping to primary coolant.

Unusual Occurrence Reports - Reports that describe events that have occurred that affect the performance, reliability or safety of a facility.

Assumptions

1. That each trainee is a certified reactor operator or supervisor.

Limitations

1. This training is specific to the High Flux Beam Reactor and is not suitable for other research reactors without modification.
2. This training only deals with cognitive knowledge. The skills in responding to actual plant events must be evaluated by the use of in-plant drills.

Methods and Procedures

This retraining program unit was designed using the instructional system design model. This process includes five phases, i.e., analysis, design, development, implementation and evaluations. In the analysis phase 3 types of analyses were conducted, a needs

analysis, a job analysis, and a task analysis. In the design phase instructional objectives, test specifications, materials to be used, instructional strategy, and evaluation methods were developed. In the development phase learning events and activities, a lesson plan, student materials, selection of media, and test questions were completed. The instruction was given in a classroom setting with an instructor acting as a facilitator. Evaluations of both the training process and the results of training were performed.

Analysis

A needs analysis, job analysis, and task analysis was conducted to identify the training requirements. The needs analysis identified the requirement for annual classroom training on the use of emergency procedures. It also determined the need to use actual plant occurrences for the development of problem scenarios to be used in this classroom training. The job analysis determined the skills, tasks and competencies needed by the operators to use the emergency procedures in dealing with plant occurrences. A search was made to compile a list of all those events that had caused the shutdown of the reactor during the last 15 years. A total of 67 events were found. These events were placed into ten major categories for discussion in the classroom.

A task analysis for each emergency procedure was performed to develop the cognitive learning objectives that are necessary for classroom discussion.

Design

In the design phase of the project the instructional objectives, test specifications, materials to be used, instructional strategy, and evaluation material were developed. A plan of instructional events was developed which laid out the instructional strategy for this unit.

Learning objectives were developed for each emergency procedure used in the plant. From these learning objectives descriptive material was prepared to be used as handouts for the lesson and self-study material for subsequent classroom discussion.

The instructional strategy developed was that the activities take place during the class as follows:

1. Review of the events causing reactor shutdown over the past 15 years (2.5 hour presentation).
2. Problem solving session using the plant emergency procedures (2.0 hour session).
3. Review of learning objectives for emergency procedures. (.5 hour session) Test questions were developed for a two hour written examination which was given to each of the groups participating in the training.

Development

In this phase a lesson plan for delivery of the instruction was developed, instructional media was selected, and the necessary materials prepared. Flipcharts were prepared to use in the classroom discussion of events causing shutdowns. Copies of each unusual occurrence were made for the instructor's use in the classroom. The instructor was

required to study the material prior to the class. Key points to discuss were noted in the lesson plan. Six problem scenarios were written. Two to three events were covered with each class. Learning objectives and descriptive material for each emergency procedure were prepared to be used as self-study material. These materials provide the rational for the use of each of the steps in each procedure. A post test question pool and examinations for the material covered by this unit were prepared.

Implementation

A study guide was sent to each of the participants prior to the scheduled class. This study guide includes the learning objectives for each of the emergency procedures to be covered in the classroom lecture. A trained instructor leads the class discussions. First, a review of the occurrences that have caused reactor shutdowns over the past 15 years are conducted. Next, a problem solving session is held with each class. The instructor facilitates discussion on the learning objectives of each procedure as solutions to the problems are discussed. Each class is broken up into groups to study and report back on their solutions to each situation. Critiques with the class are held on the solutions.

This training was given five times as each shift rotates to the day shift. Similar training will be developed annually using this unit as a model to meet the requirements of the HFBR Training Plan.

Evaluation

One-on-one and small group evaluations were conducted using the operating staff. A senior operator reviewed the lesson plan and his suggestions were incorporated into the lesson plan. Revisions to the lesson plan were also made after the first two groups were taught. Changes were made to certain problem scenarios. These changes had to be made since it was found that they were not stated clearly as the event could not take place as planned. Other formative evaluations performed were written examinations and observations of operator performance during in-plant drills. As a result of this instruction, the operators now realize that they must have a clear "understanding" of plant behavior in order to carry out the emergency procedures. However, additional in-plant drills and a plant simulator are needed in order to raise the confidence level of the results.

Summary

This instructional unit affected a change in behavior on the part of operators. Prior to this instruction, there was an attitude that if an emergency occurred all the operators had to do was to follow the emergency procedure. The instruction gave the groups insight into first hand real world problems and their solutions. The problem situations discussed enabled the operators to deal more effectively with plant problems that required the use of more than one emergency procedure. Evaluations have shown that the operators knowledge of plant limitations and behavior during emergencies as well and their competency level in demonstrating proper performance during in-plant drills has increased.

CHAPTER 2

ANALYSIS

Introduction

In order to identify the training requirements for this instructional unit 3 types of analyses were conducted, a needs analysis, job analysis, and a task analysis. Training needs were determined from DOE regulatory requirements, the HFBR existing Training Plan requirements and by conducting discussions with operations personnel and management. This review determined the need for annual classroom training on half the emergency procedures with in-plant drills covering the remainder. It also determined the need to use actual plant occurrences for discussion and the development of problem scenarios to improve operator diagnostic skills when using these procedures.

A task analysis was performed to determine the skills and knowledge necessary to perform each emergency procedure. The knowledge portion of each task was represented by developing learning objectives for each emergency procedure. These learning objectives along with descriptive material explaining the use of each procedure were reviewed by subject matter experts prior to being published as study material in a Plant Descriptive Manual. This material was developed to assist the reactor operators to review the emergency procedures prior to the classroom problem solving session.

Needs Analysis

The High Flux Beam Reactor during normal operations requires a minimum of plant manipulations or changes. The plant has a good operating record and the operators' duties during normal operations consist of daily rounds, running surveillance tests of instruments and controls, taking routine water samples, and manipulation of control rods to balance rod crowns at a constant power level. During shutdowns, refueling and maintenance work are accomplished. Startup consists of putting each of the process systems into operation, checking each safety circuit for operability, and making numerous checks on the plant's readiness to resume operation. It is a busy time for the operations crew. The startup checklist takes about 24 hours to complete to place the plant back into a readiness condition for restart. During each year about six to ten unusual occurrences take place which are reportable to the Department of Energy. Of these occurrences four to five involve shutdown of the reactor. Emergency procedures for shutting down the reactor and placing it in a safe shutdown condition have been in place for many years and are constantly being improved. These procedures are found in the plant's Operating Procedures Manual. In addition to emergency procedures, these manuals contain procedures for normal operations, as well as the rules and limits that the facility must be operated within.

The Basic Emergency Shutdown Procedure is the procedure that is always followed if the reactor is shutdown, either by operator action or by the plant's automatic control system whenever an out of limit condition exists requiring shutdown. This procedure requires scramming the controls rods, checking instrumentation to assure that shutdown (rapid power level reduction) occurred, and assuring that adequate core cooling exists. The procedure also directs one to other emergency procedures depending on the problem, for correcting the condition and checking the plant condition for readiness to restart. The out-of-limit conditions specified for shutdown are such that they are within the plant's technical specification envelope such that damage to equipment or danger to personnel is avoided.

In the HFBR assuring adequate core cooling means that the fuel must always be kept covered with water. Natural circulation cooling can maintain cooling of the decay heat of the fuel after a scram without any fuel damage occurring. In addition, because of the small size of the reactor a "China Syndrome" type of accident cannot happen. Even if the entire fuel core melted the molten metal would be contained by the reactor vessel which is confined in a confinement building.

Typical events that have caused shutdowns are power failures where primary coolant pumps have lost power, primary system leaks, loss of cold neutron facility coolant, personnel errors, electric equipment failures, pump failures, instrumentation failures, primary system vibration, secondary coolant system leaks, fuel cladding leaks and other failures.

In an electric power failure, loss of offsite power causes the primary coolant pumps to fail. An automatic scram occurs, and a battery powered shutdown pump and battery powered pony motor pumps provide continued cooling. An emergency generator starts providing power for instrumentation, lighting, running shutdown pump and other necessary equipment. In a primary system leak situation where coolant is leaking at any point, the operator is required to shutdown the reactor, depressurize to reduce the leak and have the leak repaired prior to restart. For any out-of-limit condition, unusual vibration in the primary system, or fuel leak, shutdown is also required. These events are handled in a normal fashion without any danger to the core.

Additional emergency procedures to cover anticipated events that could possibly occur which the Basic Emergency Shutdown procedure directs the operators to during an emergency are:

1. Primary System Rupture Procedure
2. Flow Reversal Procedure
3. Procedure in the Event of an In-Core Fuel Cladding Failure
4. Corrective Action Procedures for Accidental and Emergency Alarms and Shutdowns
5. Electric Power Failure Procedures
6. Secondary Water Isolation
7. Dumping Poison Water

8. In-Vessel Experimental Facility Thimble Leak
9. Compressed Air Failure Procedures
10. Building Evacuation Procedure
11. BNL Emergency Response Plan

Because the plant emergency procedures are vital to maintaining the reactor in a safe condition and protecting the plant and the public, annual training in their use is required. The Department of Energy, by its Order DOE 5480.6 Safety of Nuclear Reactors, requires its Category A reactors to conduct annual training and examination in emergency procedures. This training must be conducted both in the classroom and with control room simulators. For facilities that are small and do not have control room simulators, in-plant drills and walkarounds are an acceptable alternate.

At the HFBR the relatively short operating cycle helps to ensure that the operating crews are familiar with normal plant procedures. Many of the tasks performed during an emergency are not performed during normal operation. Additionally, normal procedures or tasks which are carried out as part of an emergency procedure may be significantly altered by the conditions existing during the emergency. To maintain operator and supervisor proficiency in the performance of these tasks, a program of emergency drills and "walk through" exercises is done. Approximately one half of the emergency procedures are covered by a drill or "walk through" exercise each year. The other half of the emergency procedures are covered each year by classroom instruction.

Previous annual classroom instruction given for emergency procedures was presented by reviewing the emergency procedures step by step with the instructor presenting the reasons for each step. This training was boring and repetitious and did not involve the participants in the learning process.

A number of staff members were interviewed to determine their reaction to the type of training being done and to get their opinions on the type of classroom training desired by them. The reactor division head stressed the need to conduct training which would test the operators' responses during emergency conditions. The operations group leader suggested that the classroom training should center on giving emergency situations for small groups to solve using the procedures. The assistant operations group leader stated that the training should stress occurrences that have caused reactor scrams and shutdowns over the past 15 years rather than concentrate on emergencies that have a small probability of occurrence. In addition a number of operators indicated that they would like to discuss situations rather than review the emergency procedures step by step, which could be accomplished more realistically during in-plant drills.

This needs analysis determined the requirements for the development of this instructional unit. It led to the development of paper simulations in lieu of a plant simulator and it led to the use of actual plant occurrences in the development of classroom situations to focus on diagnostic skills.

Approximately half of the shift supervisors have been promoted from the operator ranks. The other half are hired with engineering degrees and proceed through a similar program as the operators with additional training in supervisory skills and more comprehensive training in the plant's design, limitations and technical specifications.

In addition, the group has from 2 to 25 years operating experience at the facility. The mean for operating experience of this group is about 9 years. Tables 1 and 2 list the experience and education of reactor operators and supervisors.

An instruction unit for this group focusing on emergency procedures must be given annually to meet their recertification requirements.

Table 1 Experience and Education
HFBR Reactor Operators

No. of Operators	HFBR Operator Experience (Years)	Education	Experience Nuclear Navy (years)
1	2	AS	4
2	4	BS	4
1	4	AS	0
1	5	AS	6
1	10	HS	6
1	11	AS	0
1	11	BS	0
1	16	AS	0
1	25	AS	0
1	25	HS	0

HS - High School Diploma
AS - Associate Degree
BS - Bachelor of Science Degree

Table 2 Experience and Education
HFBR Shift Supervisors

No. of Supervisors	HFBR Supervisor Experience (Years)	Education	Experience Nuclear Navy (Years)
1	3	BS	0
1	4	BS	0
2	4	BS	4
1	6	BS	0
1	6	AS	5
1	7	AS	4
1	12	AS	0
1	15	BS	4
1	17	AS	0

Organizational Constraints

A control room simulator is used at most commercial nuclear power stations for hands-on training to demonstrate operational characteristics and for recognition and control of normal, abnormal, and emergency conditions. This provides the learner with an environment which dynamically duplicates the real world and which alters in direct relationship to their actions.

The HFBR does not have a control room simulator for hands-on training. The plant is used for this type of training. Research reactors are run in a different manner than power reactors. Power reactors are run continuously at constant power levels for 12 to 18 months and then shutdown for maintenance and refueling. As such the operating staff does not have the opportunity to carry out many operations in the plant. They must practice these operations on a plant simulator.

The HFBR operates on a three week cycle. It runs for three weeks at a constant power of 60 MW and is shutdown for three days. Thus 12 to 14 startups and shutdowns are performed each year. This gives the operations staff an opportunity to remain proficient in normal evolutions. However, in-plant drills must be conducted to gain practice in dealing with abnormal and emergency situations. These in plant drills are not conducted as often as necessary because of the additional man power required and the downtime of the plant associated with running drills. Walkarounds are used which can simulate the abnormal conditions.

A plant analyzer and training simulator is in the planning stages. Since many of the emergency actions are manual actions in the plant, these could be simulated on an interactive video screen. Computer models would be set up to simulate the plant's responses to the emergency actions taken. In addition, startup and normal console actions could be simulated with the use of interactive video techniques. This type of simulation would be more suitable to our facility.

Instructional Goal

The overall instructional goal of this project was to impove the diagnostic skills of operating personnel in responding to abnormal and emergency conditions. This was accomplished by establishing the following major goals for the instructional unit:

1. To increase the cognitive knowledge of the operating staff on those events that have caused scrams and shutdowns over the life of the plant and the manner in which they were handled.
2. To increase the cognitive knowledge of the operating staff on the emergency procedures by keying them to actual plant occurrences using the plant procedures.
3. To improve the diagnostic skill of the operating crews by having them solve problem scenarios of actual plant occurrences using plant procedures.

Events Causing Scrams and Shutdowns:

A search through the Unusual Occurrence Reports was made for the time period between 1973 and 1987 to compile a list of all those events that had caused the shutdown of the reactor during that time period. A total of 67 events were found and analyzed. These events were categorized into ten major categories for discussion in the classroom as shown in Table 3.

Since many of the operating staff had participated in one or more of these events, it was decided to ask them in each class to describe a shutdown event in which they participated. This description would include how they recognized the event and how it was handled using the "Basic Emergency Shutdown" and other emergency procedures. The instructor would act as a facilitator and lead the discussion on each category of events. They would have at their disposal the actual Unusual Occurrence Report and be familiar with their contents so that alternate means of handling the event could also be discussed to bring out salient facts.

Table 3 Causes of Reactor Shutdowns

Event	No. of Events
CNF - Related Events	16
Personnel Errors	11
Primary System Leaks	6
Failure of Pumps	5
Loss of Incoming Power	5
Electrical System Failures	4
Accidental Shutdown during testing of NSS	4
Fuel Cladding Failures	2
Secondary Water Pipe Leak	2
Miscellaneous	12
TOTAL	**67**

Keying Plant Occurrences to Use of Emergency Procedures:

A series of problem scenarios was prepared using actual plant occurrences to test the diagnostic skills of the operating crews' use of the plant's emergency procedures, scenarios were developed which required the use of two or more procedures. Some scenarios resulted in situations which were outside the procedures. In these situations higher order cognitive knowledge had to be used to decide the course of action to be taken.

A secondary goal of this instruction was to change the belief expressed by some operators that all they had to do during an emergency was to follow procedures. The behavior change desired was that they would realize that they must understand each step in the procedure to protect themselves, the plant and the public from situations in which procedures could not be followed in a step by step manner.

Self Study of Emergency Procedures:

The required entry behavior for this instructional unit was that the participants be certified reactor operators and supervisors. An instructional prerequisite was that they review the emergency procedures, the learning objectives and descriptions of reasons for each step in the emergency procedures prior to attending the problem solving session. Entry behavior for this unit of instruction requires operator knowledge and use of control room instruments and controls, and knowledge and use of all systems involved in the procedures.

Literature, Existing Course, and Material Review

A literature search was conducted at BNL library by reviewing a collection of transactions of the American Nuclear Society from 1980 through 1988. A search was also made at the NYIT Westbury Shure library. A search was done for reactor operator training on emergency procedures, paper simulation, and simulator training. Twenty papers related to this instructional unit were found. Existing course material was not found since this facility is unique and material must be prepared that is specific to this reactor. This unit of instruction requires a learning hierarchy of subjects to achieve entry level and higher order cognitive skills to diagnose plant problems. This is discussed in detail under related theory.

Related Theory

Gagne (1985) states that if the learning outcome is a cognitive strategy then the instructional technique used would be to describe the problem and show what the strategy accomplishes. If the learning outcome is attitude then the human model demonstrates the general nature of the choices to be presented. Cognitive strategies are needed to deal with plant emergencies by the plant operators.

Gagne (1985) also states that intellectual skills are based on defined concepts and rules. The organization of intellectual skills may be represented by a learning hierarchy. Subjects taught in the operator training program have a learning hierarchy in that fundamentals, systems, operating procedures and practices, and then emergency procedures are taught. Learning is cumulative. Once learners have acquired a repertoire of learning specific skills the transfer of learning multiplies. These cumulative effects of learning are the basis for observed increased intellectual "power" in developing human beings.

Paget (1988) states that the advantage of case methods are that they deal with real problems and put the trainee in the role of the person having to make a decision. The realism takes place because the discussion in the group can also provide insight as to other means of handling the situation.

In case studies participants receive the problem situation in sufficient detail so that they can recommend appropriate action. However, instructors need to pose problems that are within the range of their students' abilities. The student does not learn problem solving skills by being in perpetual confusion, but rather by success in solving more and more difficult problems. The instructor must also make each case relevant to the learning objective desired.

Control of the discussion of the problem comes about through:

1. Setting time limits for the discussion.
2. Describing the desired output.
3. Providing a list of questions for the group to answer.

These precepts were followed in developing the problem scenarios for this instructional unit.

Social Learning Theory, Bandura (1981) can be used to change attitudes and/or behaviors in the workplace. Learners can observe and imitate the models. Good models make it easier to impart knowledge and good habits. Examples provided by operators who have experienced abnormal events provide the model to imitate if the event recurs. The discussion led by a facilitator also models behavior expected during these events.

Gestalt psychologists (1981) believe that "rote memorization," the learning of senseless material by repetitive drill, was an inefficient and rarely used mode of learning in real-life situations. People learn most things in every-day life by understanding the event or grasping the underlying causes or rules. An array of information is best learned by understanding how it fits together. In developing training "Gestalt Theory" stresses that materials learned by understanding the reasons, or the rules, underlying the phenomenon are retained longer and more easily transferred than the same material learned by rote memorization. Students learning mathematics rapidly forget meaningless formulas unless they learn the concepts underlying the formulas. Material presented should relate to the needs of the person being trained. Answering the question: "How is the material going to be used on the job?" is important.

The Gestalt method of learning is very much in evidence in the training of operators. The reactor operator training program stresses learning the "reasons" behind the rules, limits and procedures under which the facility is operated. The operators are trained to understand each of the steps in the operating procedures. They are instructed in the theory of nuclear reactors as well as radiological protection so that their "insight" is improved and they have the ability to analyze and decide the safest course of action when things fail at the facility.

Bynner (1962) stated the following:

> A leader is best
> When people barely know that he exists
> Not so good when people obey and acclaim him
> Worst when they despise him...
> But of a good leader, who talks little,
> When his work is done, his aim fulfilled
> They will all say, "we did this ourselves"

Carl Rogers called this approach to learning facilitative because he "sees the role of the instructor as a facilitator rather than a controller of the learning process." This approach gives back to the students part of the responsibility for their learning process. Solving problem situations gives the student a role in taking responsibility for his learning.

The problem scenarios used for classroom discussion were developed using these principles. To develop higher order cognitive skills, it was decided to develop problem scenarios that required the use of one or more procedures, and scenarios that were not covered by step by step procedures. These problems would test the operators' knowledge of the plant and require them to combine actions from various procedures as well as make

decisions which would require their use of all of the major categories in the cognitive domain stated by Bloom (1956).

Major categories in the Cognitive Domain:

Knowledge - recognition and recall of facts and specifics.

Comprehension - interprets, translates, summarizes, or paraphrases given information.

Application - use information in a situation different from original learning context. Require comprehension of information to apply to new situation.

Analysis - separates whole into its parts, until relationship among elements is clear. Requires ability to apply information in order to analyze.

Synthesis - combines elements to form new entity from original one. Requires analysis in order to synthesize.

Evaluation - involves acts of decision-making, judging, or selecting based on criteria and rationale. Requires synthesis in order to evaluate.

Literature Review

A search was conducted at the BNL library and the NYIT library for appropriate articles that focused on emergency procedure training. Twenty articles were found. Out of these, the following articles are abstracted as pertinent to operating experiences and emergency training:

1. **Heltemes, C.J., (1987). The Lessons of Operating Experience, ANS Summer Annual Meeting, June 7-11.** This paper was presented at the 1987 Annual Meeting of the American Nuclear Society held in Dallas, Texas. The author works for the Office of Analysis and Evaluation of Operational Data, of the Nuclear Regulatory Commission. He states that "the fundamental root causes underlying significant operational events includes design deficiencies and human performance problems. Operating experience through the collection, assessment and feedback of operational events, provides the means to know, understand, and judge the adequacy of current levels of protection against such events." To minimize these events an effective operational experience assessment program is necessary at each plant. Simulator training involving multiple failures is necessary to assure realism, the support and knowledge proved by training and plant procedures is vital for proper operator performance.

2. **Jusselin M. (1987). The Training of the PWR Staff at EdF, 13th Biennial Conference on Reactor Operating Experience, Aug. 30 - Sept. 3.** This paper was presented at the 13th Biennial Conference on Reactor Operating Experience, an International Meeting on Nuclear Power Plant Operation. This article describes the training and retraining programs provided by Electicite' de France for its operating reactors. This utility is now operating thirty-two 900 MW and nine 1300 MW pressurized water reactor units.

Once a year, operators have to be retrained for a week on full scope simulators. This training includes normal operations, operations on incidents and operations on accidents. Senior reactor operators are also trained on the physical phenomena accompanying

accident situations, on diagnosis of the state of the installation after a downgraded period, and on the emergency plan procedures to be followed in the case of radiation releases from the plant due to postulated accidents.

They believe that "the safety of a nuclear installation relies so much upon the competence of the people in charge of maintaining and operating it that it is imperative to give the highest priority to the training that will achieve that goal." They emphasize the following in their programs:

a. encouraging feedback to motivate skill maintenance

b. introducing safety concepts and operating safety analysis in training to establish permanent safe behavior

c. developing typical safety actions

d. developing new training means such as microcomputers connected with expect systems in all plants that could simulate accidents

e. performing accident training and emphasizing the importance of retraining

f. using an instructional method that not only provides the knowledge necessary for the skills needed for the industry but also develops the adaptability of the individual who can then move from the original responsibilities to those of a higher order.

3. **Hamlin, K.W., (1987). Training to Handle Unexpected Events, 13th Biennial Conference on Reactor Operating Experience.** This paper was presented at the 13th Biennial Conference on Reactor Operating Experience in the "Excellence Through Training" session. The author is a member of the Institute for Nuclear Power Operation. He states that a key element in coping with unexpected events is the operators' ability to "think." Using basic knowledge and skills the operating crew must be able to analyze any given situation and arrive at a logical course of action. Improvement in operator training should support the goal of enhanced diagnostic skills.

Areas that are being enhanced include teamwork training, diagnostics training, expanded simulator training programs, improvements in simulator instuctor training, emergency procedures training, and training on the use of probabilistic risk assessment studies. All of these efforts are aimed at the goal of improving the plant staff's ability to cope with unexpected and off-normal events.

4. **Naser, J., Cain, D., Colley, R., Hirota, (1987). Artificial Intelligence Tool Development and Applications to Nuclear Power, ANS Winter Annual Meeting Nov. 15-19.** This paper was presented at the 1987 winter meeting of the American Nuclear Society held in California. The authors performed this research to help the electric utility industry take advantage of expert system technology. It reports on a number of expert system applications for the electric utility industry that are currently being developed by the Electric Power Research Institute, some of which are summarized below:

a. A system to help operators select and apply operating procedures during plant emergencies.

b. A system to perform system monitoring, sensor signal validation, fault location and diagnosis, and automatic control and reconfiguration.

c. A system for analyzing reactor trip conditions and determine whether an anticipated transient without scram had occurred or a shutdown was normal or abnormal.

5. **Feuer, D., (1985). Training at Three Mile Island Six Years Later, Training, PP 29-40.** This article discusses the accident and the impact it had on new directions for operator training. Training emerged as a major area of concern. Post-hoc analyses of the accident sequence revealed that operators could have prevented major core damage if they had recognized that coolant was escaping from the primary system through the stuck open pressurizer relief valve. The problem was that operators had been trained to suspect such a loss-of-coolant episode only in the case of a major pipe rupture known as the "big break scenario."

Experts agreed that less reliance on memorized procedures and a better understanding of the plant systems would have helped operators respond correctly to the emergency situation. In the end, the Three Mile Island (TMI) operators on duty lacked the system comprehension they needed to set the problem straight. Both industry and government reviews pointed out the need for enhanced training in responding to emergencies, especially those unforeseen situations for which there are no prescribed and practiced procedures to follow.

Also described is a "Basic Principles Training Simulator" (BPTS) purchased by the utility to enhance training. This device simulates the response of the system to a vast array of manipulations. The display panel consists of a mimic drawing of TMI systems and corresponding switches, meters and annunciators. Major controls and certain parameter displays are located on the control panel. Three CRT's show plant trends and selected calculated data. Trainees sit down at the controls, manipulate the system and readily observe the integrated plant response. While the BPTS helps operators understand the principles underlying normal and abnormal plant operations, it does not give them practice in performing actual behaviors required on the job. For that purpose the utility has built a full scope replica simulator which duplicates the TMI control room down to the last detail.

In addition to the use of simulators since the accident, operator training has expanded in many other areas. They must now spend many more hours in classroom based training and go through longer on-the-job stints in the control room before they complete their training. Senior reactor operators as well as shift supervisors, shift foreman and other supervisory personnel participate in a five-day supervisory development course and a three-day decision analysis class. They must also participate in re-qualification programs once every seven weeks for four to five days. These programs focus on new topics required by the Nuclear Regulatory Commission, on weak areas of training identified by periodic reviews of exam results, and on plant modifications and procedural changes.

6. **Oberle, J., (1990). Teamwork in the Cockpit, Training PP 34-38.** The author states that "after years of drilling pilots in technical skills and emergency procedures, airlines now suspect that training in teamwork and communication skills can keep more planes in the

air. The problem is that good pilots who are technically proficient are the ones crashing the airplanes. They don't respond in a way that mobilizes all available resources. They don't use the ability of their crew to find a solution available to them. In one crash when the landing gear was in place but the light failed to illuminate the captain was so focused on solving the problem that he did not hear the second officer state that the plane was low on fuel and kept the plane in a holding pattern until it crashed."

This accident caused by human error spurred the airline industry to study a number of accidents and "incidents" resulting from human factors. The upshot was a new type of training to improve communication and teamwork among members of flight crews. The crew-concept approach to training is altering traditional airline training methods which for years have used flight simulators to train pilots in emergency procedures. In these simulators a controller throws every possible emergency at the trainee. A crew-concept approach would put the entire cockpit team into a simulator and run them through a flight operation as close to the real thing as possible. This training differs from previous training in that the point usually is not to confront the pilot or crew with a series of emergencies but to include such routine situations as a taxi down the runway, a takeoff, minor equipment malfunctions, bad weather conditions, and even irate passengers. In this concept a videotape camera is installed in the simulator and pilots are debriefed by instructors with tapes of their sessions. The instructors use the tapes to pinpoint errors in judgment, procedures or decisions, as well as to commend and reinforce proper crew performance.

Plan for Design and Development Effort

This instructional unit was prepared in 1987, and revised and evaluated in 1989. This instructional unit was designed using the instructional system design technique. The project plan and budget for the project are stated below.

Estimated Student Effort

Five classes were held for each of the four operating shifts and the relief shift. In the morning of each day a discussion of the causes of reactor shutdowns that occurred during the last 15 years was held. In the afternoon of each day the class was broken up into two groups to solve and discuss the problem scenarios. In each group a leader was appointed to arrive at a group solution using the emergency procedures. Each leader was required to present the solution to the class. The other group critiqued or added to the solution.

Project Plan

PERT and Gantt charts were created to track this project from start to finish. These are shown in Appendix B. Since the project was completed over a three year period, the charts developed are an estimate of the time necessary to complete a project of this nature.

Budget

This training was performed as part of the retraining program, required by the division training plan and DOE orders. It was given five times to a group of 22 people in the lobby conference room of the Reactor Building. The costs to the Reactor Division, shown in Table 4, were associated with materials for the program, instructor costs, typing costs and refreshments. The total costs were $15,350 with a cost per student of $614.

The Reactor Division budget for operating the facility is approximately $12 million per year. The costs to replace the plant and experimental facilities today would be in the order of $500 million. The retraining costs of this unit to assure proper responses during an emergency are insignificant compared to these costs.

Table 4 Project Budget

Expense	Designer Hours	Other Hours	Cost	Subtotal	Total
Labor					
Analysis	100		$4,000		
Design	80		3,200		
Development	120		4,800		
Implementation	40		1,600		
Evaluation	30		1,200		
Total Labor				$14,800	
Materials					
Student Materials			$ 300		
Stationary Supplies			150		
Refreshments			100		
Total Materials				$ 500	
Grand Total					$15,350

Summary

A needs analysis led to the development of paper simulations and the use of actual plant occurrences in situations presented in the classroom for this unit of instruction. Instructional goals were established to improve the diagnostic skills of operating personnel in responding to abnormal and emergency conditions. A task analysis was performed which developed the knowledge and skill requirements necessary to be used in the training emergency situation. The literature review pointed out the need for the operating crews to be able to analyze any given situation and arrive at a logical course of action. The collection, assessment and feedback of significant events in operator training provides them with greater ability to cope with unexpected events.

CHAPTER 3

DESIGN

Introduction

The analysis phase determined the causes of reactor shutdowns over the past 15 years and the need for recognizing each event and the actions needed to be taken to mitigate the event using the emergency procedures. Based on this analysis, the design phase of this project resulted in the establishment of a training development plan which provided a "blueprint" which guided the creation of the training materials and strategies. Instructional objectives, test specifications, materials to be used, instructional strategy, and evaluations were developed. Instructional objectives were established for the operators to increase their cognitive knowledge of dealing with events causing reactor shutdown and their ability to solve problem scenarios using the plant procedures. Cognitive subskills, performance objectives and test items were developed which were used for evaluation of the instruction for those events. Next an instructional strategy was developed which determined the content, instruction method and media to use for the unit. For the review of events causing shutdown the instruction method selected was lecture/discussion with the media used to be printed matter, flipcharts and the use of an overhead projector. For the problem solving session the instruction method selected was case studies with the media used to be printed matter, flipcharts and a whiteboard. Evaluation methods selected were written examination and critiques of in-plant drills.

Instructional Task Analysis

The needs analysis determined that the classroom portion of the training should accomplish the following goals:

1. Increase the cognitive knowledge of the operating staff on those events that have caused scrams and shutdowns over the life of the plant and the manner in which they were handled.
2. Increase the cognitive knowledge of the operating staff on the emergency procedures by keying them to actual plant occurrences.
3. Improve the diagnostic skills of the operating crews by having them solve problem scenarios of actual plant procedures.

The skills, tasks and competencies needed for the operators to handle situations or events requiring plant shutdowns are given in the job task analysis sheets in Appendix A. These tasks sheets describe both the cognitive and motor skills necessary to perform each task. For this instructional unit the cognitive skills were taught in the classroom. Motor skills are tested annually by the use of in-plant drills.

Additionally, learning objectives were developed for each emergency procedure used in the plant. These learning objectives detailed the knowledge requirements needed to carry out each emergency procedure. From these learning objectives descriptive material was prepared to be used as handouts for the lesson and self study material for subsequent classroom discussion. Appendix C contains these learning objectives for the procedures which were either discussed in this instructional unit or required for self study by the operators in the evaluation phase.

1. Basic Emergency Shutdown Procedure
2. BNL Emergency Response Plan
3. Flow Reversal Procedure
4. Procedure in the Event of an In-Core Fuel Cladding Failure
5. Compressed Air Failure Procedures
6. Corrective and Emergency Procedures During Fuel Handling Operation
7. In Vessel Experimental Facility Thimble Leak Procedures

Instructional Objectives

The instructional objectives should describe the end of training behaviors that the operators must demonstrate as proof of mastery of the course content Piskurich (1987). The behaviors expected from this instruction are:

1. Cognitive knowledge of dealing with events causing reactor shutdown.
2. Solve problem scenarios using plant procedures in a classroom environment.

Appendix D provides the cognitive subskill, the performance objectives, and the test items which the operators must demonstrate to master for that portion of this instruction dealing with events causing reactor shutdown. Additionally, the learning objectives given in Appendix C are required pre-entry knowledge. Problem scenarios were developed to test operators' cognitive knowledge in the use of the plants' emergency procedures.

Written requalification examinations are given annually on emergency procedures after this instructional unit is taken. A passing grade is 80 percent. Performance mastery for carrying out procedures is a goal of 100 percent.

Entry Behaviors Defined

The entry requirements for this unit of instruction were that the person be a certified reactor operator or shift supervisor. In addition, it was required that they review the emergency procedures prior to attending the classroom problem solving session. Entry behavior requires operator knowledge of the procedures, knowledge and use of control room instruments and controls, and knowledge and use of all systems involved in the procedures.

Group and Sequence Objectives

The unit of instruction was sequenced to cover events that caused reactor shutdown first and then problem scenarios to solve using plant procedures. This sequence stresses first the use of the "Basic Emergency Shutdown Procedure" and then how this procedure leads to other procedures depending on the extent of the problem. The learning objectives given in Appendix C for each procedure are sequenced to give the symptoms of the problem, the corrective actions to take and the supplemental considerations when using the procedure.

Learning Activities Specification

Prior to each class the operators were sent a schedule of the instruction to take place and a packet of study material. This schedule is shown in Appendix E.

The class began with a review of the occurrences that have caused reactor shutdowns over the past 15 years. At the beginning of each class each operator and supervisor was asked to recall an event they participated in which caused a reactor shutdown, or when a decision was made to shutdown the reactor because of an "out of limit" condition. They were asked to describe the details of the event, the problems they encountered, and how the event was handled. This provided training in both the affective and cognitive domains.

Next an overview of the material to be presented for this unit of instruction was given to the class. The instructor stated that the following activities will take place during the class session:

1. A review of the 67 events causing reactor shutdown over the past 15 years (2.5 hour presentation).
2. Problem solving session using the plant emergency procedures (2.0 hour session).
3. Review of learning objectives for emergency procedures not covered in 1 and 2 above (0.5 hour).
4. Summary of session (0.5 hour).

The instructional strategies used are summarized in Table 5.

The instructional activities used a facilitative approach to training. The operators were asked to develop the categories of events that have caused shutdowns over the past 15 years. Their answers were written on a whiteboard. After all the categories were developed and written they were compared against flipchart data shown in Appendix F.

For each category of events the operators were again asked to list each type of failure they had experienced or read about. They were asked to recall and describe the event in which they had participated. Again, the events developed were compared against the flipchart data. The instructor described those events that the class was not familiar with and directed questions to elicit responses from the class as to what they would have done under those circumstances. Each class was asked to describe what procedural changes in

Table 5

Emergency Procedure Training Instruction
Strategy Matrix

Learning Activity	Content	Instruction Method	Media
1	Review of events causing shutdowns	Lecture/Discussion	Printed Matter Flipcharts Overhead projections
2	Problem Solving Session	Case studies using group members	Printed Matter Flipcharts Whiteboard
3	Review of Learning Objectives	Lecture/Discussion	Printed Matter Flipcharts
4	Summary	Lecture/Discussion	Printed Matter Flipcharts

operation had come about due to any of the unusual events discussed. The events discussed are listed in the class lesson plan given in Appendix G.

For the problem solving session each class was broken up into groups of two or three. A leader was appointed to facilitate each group arriving at an appropriate method of placing the plant in a safe shutdown condition using the plant's emergency procedures. The leader presented the group's solution followed by a critique involving the other groups adding or suggesting alternate approaches. Each group worked on the same problem. The instructor picked the group to present its solution. This ensured that each group worked on the problem since they did not know in advance whether or not they would be picked to present their case.

Gagne's (1985) nine steps of instruction were used in developing the learning activities specification for this instructional unit. These are summarized in Table 6.

Assessment System Specification

Each of the five groups were required to pass a 2 hour comprehensive examination on the emergency procedures discussed in this instructional unit with a minimum grade of

80 percent. This unit is given annually as part of the operators' recertification process. These examinations are evaluated to determine weak areas to be stressed in the next year's training. In-plant drills are run, critiqued, and also evaluated. This provides an additional mechanism for adding necessary changes to the instruction. Additionally, unusual occurrences are analyzed to determine additional training needs for this unit.

Table 6

Internal Processes and Their Corresponding Instructional Events

Internal Process	Instructional Event	Action
Reception	1. Gaining Attention	Asking each operator to recall a shutdown in which they participated
Expectancy	2. Informing learners of the objective	Presented overview of class events and expectations
Retrieval to Working Memory	3. Stimulating recall of prior learning	Pre-study of emergency procedures and recall of previous events
Selective Perception	4. Presenting the stimulus	Facilitative development of categories of events causing shutdowns. Problem solving session
Semantic Encoding	5. Providing Learning Guidance	Directing questions to elicit responses desired by students. Providing input as necessary focusing on learning objectives
Responding	6. Eliciting Performance	Requiring operators to solve problem scenarios and participate in class discussion
Reinforcement	7. Providing feedback	Keeping class focused on problems and solutions. Rewarding proper responses. Correcting others.
Retrieval and Reinforcement	8. Assessing Performance	Assessing class participation through questioning techniques. Assessing group solutions to problems.
Retrieval and Generalization	9. Enhancing retention and transfer	Written exam and evaluation of in-plant drills

Evaluation System Specification

Evaluation requires both formative and summative methods. These are continuing processes that result in changes to continually improve operator performance. Also, changes to plant procedures are continually being made to upgrade plant safety. This results in changes to the training to keep the operators up-to-date on the latest underlying safety considerations as well as the knowledge and skills to carry out each emergency procedure.

Formative

A one-on-one evaluation was conducted by having an operator review the lesson plans. This resulted in revisions to the lesson plans and some of the problem scenarios. Small group evaluations were done by giving the class to five groups. Changes were made after each class session to improve the problem scenarios and to guide the discussion to include knowledge gained. Written examinations were given using post tests. In addition, operator performance was assessed through the use of in-plant drills.

Summative

The four levels of Kirkpatrick's (1987) evaluation method were used for the summative evaluation. These are reaction, learning, behavior and results. The participants' reactions to the instruction were evaluated by both interviews and a questionnaire. The learning was assessed using written examinations and also by the instructor during the classroom discussions of unusual events and problem scenarios. Changes in operator behavior as a result of this instruction were noted through interviews with participants, peers, and supervisors and through the use of in-plant drills. The program has led to an increase in the operators' level of plant knowledge in dealing with emergencies.

Learning Transfer System Specifications

A training curriculum review committee was recently established to review new training programs as well as retraining programs to ensure job relevancy. The committee is composed of the plant manager, safety analysis group leader, instrumentation group leader, radiological protection group leader, engineering group leader, operations group leader, and the training manager. The training manager is the chairman of this committee. This committee supports transfer of learning by following Broad's (1982) recommendation that upper management involvement at the policy making level are necessary to support full use of learning from a specific training program. Training must focus in areas that management feel are important and necessary for it to be used on-the-job. The committee will review future instructional goals for this unit. Transfer of training to the job was evaluated by analyzing unusual occurrences and in-plant drills. This is a continual evaluation and feedback process.

Review and Selection of Existing Materials

Review and selection of training materials existing at other facilities was performed. None were selected since the occurrences in this unit dealt with those events which caused shutdown at the High Flux Beam Reactor. This is a unique reactor and not comparable to other facilities. Training on significant events that have occurred at other facilities such as Three Mile Island, Chernobyl, and the Savannah River Plant is done during other retraining sessions.

Summary

The skills, tasks and competencies needed for the operators to handle situations or events requiring plant shutdowns were determined using job task analysis. For this unit only cognitive skills were taught. Learning objectives and descriptive material for each emergency procedure were developed to be used as self-study material. Materials were developed to review events causing reactor shutdown during the past 15 years. Problem scenarios were developed using actual plant occurrences to be used as case studies. Lesson plans were prepared which specified instruction technique and media. Evaluation techniques were determined through the use of an assessment system specification.

CHAPTER 4

DEVELOPMENT

Introduction

In the analysis and design of the project the training needs were defined and guidelines were mapped out for instructional solutions. The development of this instructional unit involved selecting learning events and activities and developing a lesson plan for delivery of the instruction. Problem scenarios were developed based on actual plant occurrences for the operators to solve using plant procedures in the classroom. Learning objectives were developed which were sent to the students, along with a copy of each procedure prior to the class. These objectives along with the rationale for each step in each emergency procedure are included in the HFBR Plant Description Manual which was used for self study in preparation for the class and post test. The output of the development phase were student materials, instructor materials, selection of media, and test questions.

Learning Activity Development Scheme

A lesson plan was developed as shown in Appendix G. This lesson plan had three major objectives:

1. Overview of history of occurrences that caused reactor shutdowns.
2. Self study of emergency procedures.
3. Classroom problem situations using emergency procedures.

The plan was to have an instructor facilitate the discussion on occurrences that have caused reactor shutdowns as well as the problem situations using the emergency procedures. Prior to each class the operators were sent a package of self-study material. This self study package included the learning objectives and plant descriptive manual sections for each emergency procedure that they would be tested on in the post test. This was necessary since the six hour class session did not cover all the procedures.

It was interesting to note that during the classroom discussions on occurrences that have caused reactor shutdowns, details of the events were recalled that were not mentioned in the written reports. These type of discussions perked up the interest of the entire group. During the classroom session each operator and supervisor in turn was asked to describe an event in which they had participated. They responded to this quite well and were happy to share their knowledge with the group. Only one or two operators of the twenty-two had not participated in an event causing shutdown. The group learned from their peers and the discussions were lively compared to previous sessions in which little interest was shown.

Learning Activity Development

The lesson materials were developed over a three month period for this instructional unit. A search was made through the unusual occurrence reports for those requiring

shutdown of the reactor. Sixty-seven reports were found. These were categorized and flip-charts were prepared for the classroom discussion of these events. The flipcharts used are shown in Appendix F. The events were categorized into ten major headings with each major heading discussed in the classroom.

1. CNF - Related Events
2. Personnel Errors
3. Primary System Leaks
4. Failure of Pumps
5. Loss of Incoming Power
6. Electric System Failures
7. Accidental Shutdown During Testing
8. Fuel Cladding Failures
9. Secondary Water System Pipe Leaks
10. Miscellaneous

Copies of each unusual occurrence were made for the instructors' use in the classroom. The instructor was required to study the material prior to the class. Key points to discuss are noted in the lesson plan. Next, problem scenarios were developed as shown in Appendix H. Six events were developed. Only two to three events could be covered with each class in the time allowed. Revisions had to be made to the scenarios due to comments made by the first and second groups.

Learning objectives were developed for the emergency procedures. These learning objectives, along with a copy of each procedure that the operators were responsible for in the post test, were sent to each group prior to the class. Learning objectives and descriptive material for each emergency procedure had been prepared prior to the class and included in the HFBR Plant Description Manual. These materials provided the rationale for the use of each procedure. They also describe the technical reasons for each step and provide supplementary material that aid the operator in the use of a procedure. This promotes an "understanding" on the part of the operators as to what is being done and why. A post test question pool for the procedures covered by this class was prepared as shown in Appendix I.

Learning Activity Review

The lesson plan for this instructional unit was written and approved by the designer. The plant emergency procedures were written by the operations group leader and approved by the reactor division manager. The learning objectives and descriptive material for each emergency procedure found in the plant descriptive manual were written and approved by the designer and reviewed by the operations group leader. Copy editing was done by the secretarial staff, the designer and the procedure manager. Test questions were reviewed by another trainer for technical content accuracy.

Future lesson plans will be required to be reviewed by a subject matter expert prior to use. The lesson plan and materials were reviewed by a shift supervisor for technical accuracy and corrections were made.

Materials for Evaluation Produced

Materials were prepared and the lesson given to five groups during a five week period. The evaluation of this unit of instuction is an on going process. As each unit is given each year on a repeated basis, the operators should develop an expanded knowledge of the interrelations of the plant system during abnormal events and emergencies. Revisions are made each year to include new problem situations and unusual occurrences.

Summary

The lesson plan describes how the instructor and trainees will perform during the training to achieve the learning objectives. Training materials were produced and selected which were appropriate to the procedures being discussed. Resulting training materials were reviewed for accuracy prior to use. The lesson was tried out with five groups of trainees and revisions were made as a result of their comments. The groups felt that the teamwork needed to solve the scenarios in the classroom, as well as the review of past experiences, were helpful in their jobs.

CHAPTER 5

IMPLEMENTATION

Introduction

This instructional unit was developed to improve the diagnostic skills of operating personnel in responding to abnormal and emergency conditions at the High Flux Beam Reactor. Actual plant occurrences were used to develop classroom paper simulations for reactor operators to do case studies on how they would handle these situations.

The materials used in the classroom were copies of the emergency procedures, a flipchart presentation which summarized categories of events that have caused shutdowns over the past 15 years, and problem situations to conduct classroom paper simulations of these situations using the plant emergency procedures as reference materials. The instructor acted as a facilitator and had the class develop the categories of events that caused shutdown. These events were reviewed with the class along with the actions taken to resolve the situation. After the review session the paper simulation session took place. Each group was given two to three situations to solve and summarize for the class.

Materials for Implementation Reproduced

After revisions to materials were completed, two copies of the lesson plan were made. One for the instructor and one for the quarterly retraining file. Forty copies of the student handout material, the learning objectives shown in Appendix C and the flipchart handouts shown in Appendix F were made and distributed in the classroom. Twenty-five copies of the problem scenarios shown in Appendix H were made to be used in each of the five classes. Twenty-five copies of each emergency procedure to be used was made and distributed in each class as student handouts. Prior to the class 30 copies of the class schedule, learning objectives and emergency procedures were made to send to the students.

Instructional Delivery

Classroom Setting

Each of the five classes was held starting at 9:00 a.m. Wednesday morning with the written examination scheduled for the following Monday morning. This gave the students the weekend to study for the examination. Each class was held in the lobby conference room of the reactor building. The persons in attendance were seated around a rectangular conference table. A flipchart and blackboard at the front of the room were used.

Presentation Method

The first part of the presentation was to review the occurrences that have caused reactor shutdowns over the past 15 years. To begin the session each supervisor and operator was asked to recall an event in which they participated that resulted in a shutdown. They were asked to describe the manner in which the event was handled on their shift. The objective of the first part of the lesson was to gain the attention of the operators. The response to this opening session was enthusiastic. Events were recalled that had not been written up as unusual occurrences but which some operators thought were significant. Discussions were lively.

After discussing their individual experiences each class was asked to develop the categories of events that had caused reactor shutdowns over the past 15 years. Their answers were written on the blackboard. After all their replies were listed they were compared with the flipchart data. The flipchart data shown in Appendix F had been prepared in advance of the lecture and consisted of six sheets. The first sheet of the chart summarized the categories of events that have caused shutdowns and each additional sheet summarized each of the categories. The classes were able to list all of the major categories with some prompting from the instructor.

Next, each category of events was discussed. The class was asked to recall the event and state how each event was handled. The instructor acted as a facilitator and solicited responses from the group on how they would have handled each type of event. The class was provided the handout material shown in Appendix F. The opening session where each operator recalled an event in which they participated lasted about one hour and the discussion of events took about two hours. This completed the morning session.

The afternoon session was devoted to problem solving. Each class was divided into two to three small groups. Each group consisted mainly of a supervisor and an operator, some groups consisted of two supervisors or two operators, depending on the mix of the class. The smallest class had three people while the largest class size was seven people.

Each session lasted approximately three hours and was conducted as follows:

1. Each group was given the same event to solve. The emergency procedures were given to each group to use as a guide for handling the situation.
2. A leader was appointed in each group to present to the class the solution or manner in which the group decided to handle the situation.
3. The other groups in the class were asked to critique or add to the solution or state the manner in which they would have handled the event.
4. The instructor acted as a facilitator to reinforce the learning objectives for each problem event.
5. Two to three events were discussed in each class depending on their length. The events or problem scenarios that were discussed are shown in Appendix H.

The problem scenarios were written so that each scenario required the operator to use one or more procedures to arrive at a safe shutdown condition. In addition, some of the scenarios were not completely covered by the emergency procedure. As an example, problem scenario #2 is not the result of an emergency but is caused by personnel error in draining the reactor vessel. Action required is to assure that the reactor is safely shutdown and then restore liquid level and resume operations. Problem scenario #3 requires shutdown of the reactor, evacuation of the reactor building and activation of the site emergency plan. Problem #5 is an extended power outage situation and requires knowledge of how long battery driver emergency equipment functions and what manual actions must be taken to keep the core covered. These scenarios required problem solving skills based on the operators' knowledge of the plant.

Data Collection

A lecture critique form was prepared and data collected as shown in Appendix J to measure student reaction to the class. The form consisted of a single page and asked for opinions on the instruction. The following questions were asked:

1. Was the instruction interesting?
2. Were the problem solving sessions helpful in performing your job?
3. Would you like to see more of this done during the emergency procedure classroom training?
4. How could the situations be improved?
5. Were sufficient problem exercises included and were they appropriate?
6. Was the review of unusual occurrence reports appropriate? Was it helpful?
7. Did you receive sufficient feedback during the problem solving sessions?
8. Did the tests measure your performance on the stated objectives?
9. Did you receive sufficient feedback on your test results?

This form was sent to the participants after the class to determine their reaction to the training. Six replies to the questionnaire were received and evaluated in Appendix J. A post test consisting of a two hour written examination was given to each of the 22 participants. The post test questions were taken from the question pool. Four different examinations were prepared from the question pool. A question pool is prepared for each quarterly training session to cover all of the learning objectives and to allow for different examinations to be given for each group. Evaluations of in-plant drills on emergency procedures are done on a continuing basis. Three such drills were done last year.

Summary

Annual emergency procedure training was given to 22 certified operators and supervisors as required by the division training plan. Student handouts were reproduced, student reactions to the program were determined by a written critique form and post examinations

were given to the certified people. The class time ran approximately six hours and the post examination approximately two hours. The participants' reaction to continuing with this type of training was favorable. The majority felt that the process resulted in increased learning in dealing with emergencies. This was accomplished through participation in the problem solving situations and through learning how their peers handled abnormal situations.

CHAPTER 6

EVALUATION

Introduction

Evaluation is done to determine whether the objectives or instructional goals have, in fact, been accomplished Mager (1984). By monitoring such indicators as job performance, plant and procedure changes, and operating experience, evaluation helps maintain and improve the training program. Evaluations of both the training process and the results of the training were performed. The formative evaluation, one-on-one and small group trials, showed a need to revise the problem scenarios and instructional material. Changes were made to the lesson plan as a result of these evaluations. The summative evaluation performed considered Kirkpatrick's (1987) four levels of evaluation, reaction to the training, learning that took place, change in operator behavior, and results. This is an ongoing process as each unit is given each year on a repeated basis. The operators are developing a greater knowledge of the interrelations of the plant systems during abnormal events and emergencies. The evaluations performed were written examinations, observations of their performance during in-plant drills and interviews with operations management.

Formative Evaluation

Formative evaluation is defined to be the collection of data and information during the development of instruction which can be used to improve the effectiveness of the instruction, Dick and Carey (1985). Studies have demonstrated that simply trying out the materials with a single learner and revising the data can make a significant difference in the effectiveness of the material. There are three basic phases of formative evaluation, two of which were used in evaluating this instructional unit. The first stage used was a one-to-one evaluation where the designer worked with a student to obtain data to revise the material. It is also important to have the instruction reviewed by specialists for technical content and accuracy. The final phase of formative evaluation was small group trials. In this type of evaluation a group of students representative of the target population are presented the material and tested to collect data on the program's effectiveness. The emphasis of this stage is to try the instruction in a situation as "real world" as possible.

One-On-One Evaluation

A supervisor was selected for this evaluation who had the skills to evaluate the technical content as well as the instructional content. He was given the instructional materials which included the learning objectives, the lesson plan and the problem scenarios to review. The supervisor was interviewed and the following questions were asked:

1. What is your reaction to the lesson plan format?

2. Is the material appropriate for the skills and knowledge of the target population?

3. Does it cover the learning objectives?

4. Is it consistent with the learning objectives?

5. Is it compatible with the training plan?

6. What suggestions do you have for improving the materials?

The supervisor stated that the format of the lesson plan was unique in getting the operators involved in this instruction unit since in the past classroom training in emergency procedures consisted of just lectures. He believed that the material was appropriate for the target population and was consistent with the learning objectives, and compatible with the training plan. He had a number of comments, some of which were incorporated into the instructional unit and others which will be incorporated in future units as follows:

1. Conduct the same type of program each year using problem situations but change the type of unusual occurrences discussed.

2. Discuss occurrences that may have had a high impact on safety in addition to those causing shutdowns.

3. Discuss design or procedural changes that have resulted from unusual occurrences.

4. When discussing events get copies of recorder chart traces that existed just before and at the time of the event and use them as training aids to explain what happened.

5. Use more visual aids of systems and equipment during the presentation.

6. During the event discussion, discuss how following procedures could have prevented the occurrence.

The supervisor also suggested changes to the lesson plan. He suggested another possibility for starting the lesson by asking the question: "How many people have witnessed or participated in an event when a decision was made to shutdown the reactor because something was wrong?" This question was added to the lesson plan.

Small Group Evaluation

After revisions were made from the one-on-one evaluation, which included a technical review of the material, the material was tried out on the target population. The target population consisted of 22 certified operators and supervisors. The lesson was given to five groups over a five week period. The target population had to be used for the small group evaluation since it would not be economical to try to break up this small population into smaller groups. Also the lesson given was part of their annual certification requirements for training in emergency procedures. This was dictated by the training schedule.

During the sessions certain problem scenarios had to be changed since they were not stated clearly or the event could not take place as planned. Suggestions made by the groups for different scenarios which were incorporated into the unit were as follows:

1. Consider a leak from the differential pressure transmitter occurring after maintenance.
2. During a fuel cladding failure event instead of providing radiation levels let the group determine how they would tell what the radiation levels might be after the event.
3. Use a two inch rupture in the cleanup system as an event.

Post tests were given to each of the groups that participated in the instruction during the five week period. Results of these post tests are given in Table 7. A copy of a typical post test given is shown in Appendix K.

The test results revealed that the majority of the group were in the 90 percentile region. A passing grade for recertification is a minimum of 80 percent. Since a pretest had not been given, an accurate measure of the impact of the instruction could not be made. Pretests should be added to the program to gauge the impact of the program. Time must be allotted in future programs to conduct these pre-tests.

Pilot Test

Pilot tests were not performed because of the small size of the student population.

Summative Evaluation

Summative evaluation is defined by Dick and Carey (1985) as the design, collection, and interpretation of data and information for a given set of instruction for the purpose of determining the value or worth of that instruction. The summative evaluation of this instructional unit was done using Kirkpatrick's (1987) four levels of evaluation. These were reaction, learning, behavior, and results.

Reaction

The certified personnel attending this program were sent a questionnaire as shown in Appendix I to fill out. This provided their reaction to the program. These questionnaires also provided management's reaction to the instructional unit since the plant manager, operations group leader, and assistant operations group leader are also required to attend the program to maintain their certification. The questionnaires were evaluated. The majority of respondees stated that the teamwork needed to solve the scenarios in the classroom was helpful in their jobs. Some of the participants thought we were covering too much material in one session. All stated that we should continue to do this type of emergency procedure training. A summary of the significant comments follow:

1. Discussion among crew members was helpful.
2. Review of past experience is helpful.
3. Put time lines on problem. Put more pressure on participants.
4. Consider smaller groups with one instructor per group.
5. Class is not given often enough to have lasting effect on performance.
6. Make the training more realistic by running more in-plant drills.
7. Perform exercises in the actual time frame that events would happen.

Table 7

Emergency Procedures Test Results

Student	Raw Score	Percent
1	98.4	94.6
2	90.0	85.5
3	85.0	81.6
4	93.8	90.1
5	94.0	90.3
6	90.6	87.2
7	98.0	94.3
8	102.3	98.4
9	85.5	82.2
10	102.9	98.9
11	97.5	93.8
12	97.8	94.1
13	95.2	91.5
14	94.0	90.3
15	93.5	89.9
16	101.7	97.8
17	93.8	90.2
18	91.3	87.8
19	101.4	97.5
20	83.3	80.1
21	88.7	85.3
22	86.5	83.2
Mean	90.25 percent	
Median	90.25 percent	
Standard Deviation	5.52 percent	

Audits by the Department of Energy have criticized the division's retraining program by stating that one day per quarter is not adequate for the operations staff. Additional manpower for the training group as well as operations group has been requested to increase the retraining program classroom time to one week each quarter of the year. This will allow more time for conducting this type of training. A class devoted to problem solving situations each quarter is being planned.

Learning

An examination was given to each of the participants after the program. The test scores were summarized in the formative evaluation section. This examination showed very little increase in the knowledge of the operators since the last examination was given. The written examination scores did not increase because this session dealt with problem solving skills and the examination tests level of knowledge. The operators level of knowledge remains high because this training is repeated on an annual basis. However, during this training operators discussed how they handled certain events. This gave the group insights into first hand real world problems and solutions. The problem situations discussed also enabled the operators to be able to more effectively deal with plant problems that required the use of more than one emergency procedure. The in-depth discussions of the plant limitations also provided for a more realistic assessment of the impacts of various plant situations.

Since this instructional unit was done, a number of in-plant drills have taken place in which evaluations were done. One drill involved a contaminated injured man in which an emergency rescue was involved. In December and November of 1989 four drills were run on primary system rupture events. Results of the critiques of these drills that were fed back into this program were as follows:

1. Contaminated Injured Man Drill - Better communication between the fire and rescue group and the shift supervisor should have been established such that the fire rescue group understood the hazards involved before going into the area to help the injured man. The police lieutenant after finding out the problem should have relayed the information to the guards on the posts. Health physics should have requested urine samples from all participants in the operation to determine the dose they received during the drill. The shift supervisor who becomes the local emergency coordinator for these events should under stand that they are responsible for the actions of all the local emergency forces.

2. Primary System Rupture Drills - Cognitive knowledge was found to be adequate; however, it was found that additional training was needed on each shift. This was conducted by each shift supervisor to assure that his operating crew knows how to use the leak tape cabinets for tracking down the leak as well as the procedure to isolate sections of the system corresponding to the circuits alarmed. The drill also pointed out the need to go into more detail during the problem scenarios in how to use each step of the procedure.

Behavior

The purpose of this instructional unit was to improve the diagnostic skills of operators in responding to abnormal and emergency conditions at the High Flux Beam Reactor. Prior to this instruction, there was an attitude that if an emergency occurred all the operators had to do was to follow the emergency procedures in a step by step fashion. From the experience at Three Mile Island (TMI) the experts agreed that, in general, less reliance on memorizing procedures and a better understanding of basic principles of physics would have helped operators respond correctly to the emergency situation Fuer (1985). In the

end, the TMI operators on duty lacked the system comprehension they needed to set the problem straight. During the conduct of giving this instructional unit it was noted that the operators' knowledge of the basis for the procedures as well as the limitations of the plant, and the interrelations and synergistic effect of using combinations of procedures was weak. Changes have clearly taken place as a result of this instructional unit and other quarterly training sessions that have been conducted over the past two years. In an interview for the Brookhaven Bulletin, a weekly newsletter, one of the operators reported that the focus of training done today is to have a clear "understanding" of plant behavior as well as being able to carry out procedures. From conversations with participants, peers and superiors it is evident that behavior of plant operators has changed. Their knowledge of plant limitations and behavior has greatly increased. Their competency level in demonstrating proper performance during in-plant drills has also increased. These improvements have been noted by the written critiques done of these drills over the past two years.

Since emergencies rarely occur at our facility, it is difficult to evaluate the actual response that would be made. In order to evaluate this response a simulator would be necessary. Plans call for a plant analyzer simulator to be built in 1994. This simulator would not duplicate the physical layout of the plant, but would simulate the integrated response of the system and use CRT's to show plant trends and selected responses to events. The trainees could sit down at the controls, manipulate the system and readily observe the integrated response. The simulator would also allow the instructor to enter malfunctions, vary the speed, backtrack and alter variables to monitor the trainee's response.

Results/Impact

The purpose of evaluating at this level is to find out if the program has led to organizational improvement. Facility operating, maintenance, and industrial safety experiences are monitored on an annual basis to identify problems caused by operator errors which indicate training should be revised. Operator errors result in the generation of about 20 percent of the plant's unusual occurrence reports for a variety of causes. These causes are analyzed and where necessary retraining is performed.

This instructional unit has not resulted in a decrease in the number of personnel errors. However, through this unit and other retraining programs it is clear that the operators have increased their ability to diagnose and react to in-plant drills. The high performing group of supervisors and operators have clearly increased their level of plant knowledge in dealing with emergencies. However, two in-plant drills a year only tests the skills of 6 people out of 22 and does not provide a true measure of the abilities of all the people. Additional in-plant drills and evaluations are needed to raise the confidence level of the expected performances until a plant analyzer simulator can be built. It is presently planned to run an in-plant drill prior to each startup. This will insure that each month at least one day is devoted to in-plant drills and that each operating crew participates in a minimum of three plant drills each year.

Learning Transfer

"Unfortunately, most evaluations of training find little measureable behavioral change on the job" Broad (1982). Certain actions are necessary to make a long range change in the occurrence of those organizational problems which the training was designed to improve. Some highly rated management actions recommended by a select group of HRD leaders Broad, (1982) include:

1. Participate in training, allocation of resources for training and incorporation of training outcomes into the structure and processes of the organization.
2. Support the training program through their participation in training design development, selection and preparation of trainers, and commitment for full trainee attendance.
3. Provide time to free the trainee from all of their duties to concentrate on training.
4. Follow up actions that support the incorporation of new trainee behaviors into the on-going processes of the organization.

The training objectives for this unit in the future will be reviewed by the Training Curriculum Review Committee. This is a policy making committee composed of top management. The plant manager, operations group leader, and assistant operations group leader participate in all retraining programs to maintain their certification. Their feedback contributes greatly to the improvement of the program as well as the learning transfer. Participants in this program are relieved from their normal job duties to attend. Pre-study of the materials is also encouraged. Follow up actions include the evaluation of in-plant drills and unusual occurrences at the facility. This data is fed back into the program.

A transfer of learning has taken place because of this instructional unit. The operators have gained first hand knowledge of those events that have caused shutdown over the past 15 years and the manner in which they were handled by their peers. They have also increased their diagnostic skills and teamwork in how to handle problem situations and realize that they must understand how , when and why they are using each step in each emergency procedure.

Summary

The one-on-one evaluation and the small group trials led to suggestions which were incorporated into the instructional unit. Changes in behavior have taken place because the operators realize that they must have a clear "understanding" of plant behavior in order to carry out procedures to handle abnormal events and emergencies. A number of comments made by the participants will be incorporated into future training. Exercises will be given time limitations to put more pressure on the participants and more in-plant drills will be run to make the training more realistic. In addition more classes devoted to problem solving will be conducted in an expanded retraining program. Plans also call for a plant ana-

lyzer simulator to be built in 1994. This simulator would use CRT's to show plant trends and responses to events. The operators could manipulate the controls and observe the response while the instructor could monitor and evaluate the response. Evaluations from both in-plant drills and a simulator are needed to raise the confidence level of the results.

CHAPTER 7

SUMMARY AND RECOMMENDATIONS

Introduction

The purpose of this instructional unit was to improve the annual training of operators and supervisors in performing the plant's emergency procedures. It was designed for operators and supervisors at the High Flux Beam Reactor. This chapter summarizes the project including the methods used, and conclusions and recommendations. Its results will be useful to others who operate high risk facilities and conduct emergency procedure training.

Methods and Procedures Used

This retraining program unit was designed using the instructional system design model. The five phases of this model were used. These are summarized below, i.e., analysis, design, development, implementation, and evaluation. The training was accomplished in a classroom setting in the lobby conference room at the High Flux Beam Reactor.

Analysis

Annual training in emergency procedures is required by the Department of Energy for its Category A reactors, by its Order DOE 5480.6, "Safety of Nuclear Reactors." A needs analysis determined the requirements for the development of this instructional unit. It led to the development of paper simulations in lieu of a plant simulator and the development of classroom situations to focus on diagnostic skills. The unit focused on those events that have caused scrams and shutdowns over the life of the plant and the manner in which they were handled. A job and task analysis determined the skills, tasks and competencies needed for the operators to handle plant occurrences. The cognitive skills were selected for classroom training with the motor skills tested through the in-plant drill program.

A literature review was performed which dealt with emergency procedure training at other facilities. This review pointed out that the key element in coping with unexpected events is the operator's ability to "think." Using basic knowledge and skills, the operating crew must be able to analyze any given situation and arrive at a logical course of action. Training emerged as a major area of concern as a result of the Three Mile Island accident. Less reliance on memorized procedures and a better understanding of the plant systems would have helped those operators respond correctly to the emergency situation.

Design

The analysis phase determined the causes of reactor shutdowns, the need for recognizing each event and the actions needed to be taken to mitigate the event. The design phase of this project provided a "blueprint" which guided the creation of instructional objectives, test specifications, materials to be used, instructional strategy, and evaluation materials.

Learning objectives and descriptive materials for each emergency procedure were developed to be used as self study material. Materials were developed to review events causing reactor shutdown during the past 15 years. Problem scenarios were developed using actual plant occurrences to be used as case studies. An instructional strategy was developed using Gagne's (1985) nine steps of instruction. Based on this strategy, lesson plans were prepared, and evaluation techniques developed.

Development

Learning events and activities were selected and a lesson plan was developed for delivery of the instruction. The output of this phase was student materials, instructor materials, media used, and test questions. Resulting training materials were reviewed for accuracy prior to use. The lesson was tried out with five groups of trainees and revisions were made as a result of their comments. The groups felt that the teamwork needed to solve the scenarios in the classroom, as well as the review of past experiences, was helpful in their jobs.

Implementation

The training was delivered to 22 certified operators and supervisors. Student handouts given prior to the class were copies of the appropriate emergency procedures, along with learning objectives and descriptive materials. The class time ran approximately six hours and the post written examination was two hours. The reaction to continue with this type of training was favorable. The majority of participants felt that the training increased their learning in how to handle emergencies.

Evaluation

Evaluations included both the formative and summative processes. One-on-one and small group trials were done. These evaluations resulted in revisions to the problem scenarios and lesson plans. The one-on-one evaluation led to suggestions which will be incorporated into future units. Similar programs will be conducted each year but changes will be made to the type of unusual occurrences discussed. Occurrences that may have a high impact on safety, or result in design or procedural changes, will be discussed in addition to those causing shutdowns.

Kirkpatrick's (1987) four levels of evaluation were conducted. Reaction to the program was favorable and most participants felt that solving scenarios in the classroom was helpful in their jobs. Learning how other operators handled events that caused shutdown gave each of the groups insights into first hand real world problems and solutions. The problem situations discussed also provided the operators with a more realistic assessment of the impacts of various plant situations. Changes in behavior have taken place as a result of this instructional unit. The operators believe that the focus of training done today is for them to have a clear "understanding" of plant behavior as well as being able to carry out procedures. The results of the program have been evaluated to find out if it has led to

organizational improvement. There has been an increase in knowledge on the part of the staff to diagnose and deal with emergencies. However, additional in-plant drills and evaluations are needed to raise the confidence level of the trainees.

Conclusions

Enabling operators to handle emergency situations is the final goal of their training program. Operating experience through the collection, assessment, and feedback of operational events provides the means for operators to deal with these events. The safety of nuclear facilities relies heavily on the competence of the people in charge of operating and maintaining them. Because of this, annual training is required of operators in the use of emergency procedures. As a result of this training, the operators of the High Flux Beam Reactor developed a greater knowledge of the interrelations of the plant systems during abnormal events and emergencies. The events discussed had occurred at the facility and were real world situations.

The problem for the operators at our facility is the lack of a simulator. A simulator would enhance the training in that one could evaluate the actual response made during the event. In-plant drills allow some evaluation but their frequency and range of conditions are limited. In lieu of a plant simulator an expert system could be considered to assist the operator during emergency conditions. An expert system could help operators diagnose the event, and select, and apply the proper corrective action during the emergency.

Recommendations

Real world, abnormal or emergency situations can be discussed, but must be demonstrated using the plant or a realistic simulator for the actual responses to be effectively evaluated. In the classroom the response is verbal while in the simulator the response is action and orders to crew for actions to be carried out. The discussion phase takes place after the actions are carried out in the simulator by the group involved. The evaluation process also revealed changes to the classroom training that would enhance its effectiveness. These are as follows:

1. Change problem situations discussed each year. Discuss occurrences that may have had a high impact on safety in addition to those causing shutdowns.
2. Use more visual aids of systems and equipment during the presentation. Use recorder chart traces of important parameters.
3. Develop plant analyzer simulator to simulate the integrated response of plant systems. Interactive video and computers could be used to show plant trends and selected responses to events. In lieu of a simulator, develop an expert system to assist operators in diagnosis of operating procedures.

CONCLUDING STATEMENT

A poem by Walter Rinder titled "Being" expresses the need to provide more realistic simulation of events.

"Climb to the threshold of
your own beliefs,
not with the statement
of others
but with the footsteps of
your own experience"

Our next focus will be better simulation of events. The challenge of simulation will be whether the duplication of the plant's behavior can be done at a reasonable cost with fidelity.

APPENDIX A

JOB TASK ANALYSIS

COURSE: Quarterly Retraining

UNIT: Reactor Operators and Shift Supervisors

MODULE: Emergency Procedures

TASK: Shutdown the Reactor using the Basic Emergency Shutdown Procedure

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PERFORMANCE OBJECTIVE

Given an "out of limit" condition the trainee will shutdown the reactor using the Basic Emergency Shutdown Procedure.

ENABLING OBJECTIVES	CRITERION REFERENCE MEASURE
The student must be able to:	**The Student Did:**
Recognize the "out of limit" condition and shutdown the reactor using the basic emergency shutdown procedure.	1. Scram the reactor. 2. Check to see that at least 5 main control rods are full in. 3. Check to see that power is dropping and period is negative. 4. Check to see that reactor coolant temperature is dropping. 5. Leave primary coolant pumps running for at least 5 minutes. 6. Shutdown primary pumps and secondary water pumps. 7. Establish gravity flow to shutdown cooler. 8. Correct out of limit conditions. 9. Restart reactor.

COURSE: Quarterly Retraining

UNIT: Reactor Operators and Shift Supervisors

MODULE: Emergency Procedures

TASK: Describe what instruments to use to determine the reactor is shutdown during normal AC power conditions.

PERFORMANCE OBJECTIVE

Given a reactor scram be able to describe what instruments to use to determine that the reactor is shutdown.

ENABLING OBJECTIVES

The student must be able to:

Recognize the reactor is shutdown by observing the following instruments:

1. The control rod position indicators - at least 5 main control rods must be full in.
2. Reactor power level instruments - must drop rapidly to a few megawatts.
3. Reactor period must be negative.
4. Primary cooling water inlet and outlet instruments should indicate a drop.
5. Reactor vessel level instruments must be normal.

Be able to describe why these conditions are expected during a scram.

CRITERION REFERENCE MEASURE

The Student Did:

1. Be able to describe why 5 rods full in are necessary.
2. Be able to describe the normal readings expected during a "scram."
3. Be able to describe what action to take if less than five rods are full in after a scram.

COURSE: Quarterly Retraining

UNIT: Reactor Operators and Shift Supervisors

MODULE: Emergency Procedures

TASK: Describe what instruments to use to determine the reactor is shutdown during loss of AC power, during loss of the emergency generator.

PERFORMANCE OBJECTIVE

Given a "loss of AC power" be able to describe the instruments to use to determine the shutdown condition of the reactor if the emergency generator starts, or if the emergency generator does not start.

ENABLING OBJECTIVES	**CRITERION REFERENCE MEASURE**
The student must be able to:	**The Student Did:**
Recognize what instruments to use to determine the shutdown condition of the reactor during a loss of AC power if the AC generator does start or does not start.	1. Describe instruments to use if the emergency generator starts o control rod position indicators o reactor power level indicators o primary coolant temperature indicators o reactor vessel liquid level instrument o shutdown coolant flow 2. If generator does not start o rod position limit lights (2 hours) o power level channel 5 & 6 (2 hours) o TR-102 reactor out temperature (2 hours) o shutdown coolant flow (2 hours) o reactor vessel liquid Level

COURSE: Quarterly Retraining

UNIT: Reactor Operators and Shift Supervisors

MODULE: Emergency Procedures

TASK: Take corrective action if there is an indication of a primary to secondary leak

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PERFORMANCE OBJECTIVE

Given an indication of a primary to secondary coolant leak the trainee will shutdown the reactor and take corrective action to isolate the leak.

ENABLING OBJECTIVES	**CRITERION REFERENCE MEASURE**
The student must be able to:	**The Student Did:**
Recognize the indications of a primary to secondary coolant leak, shutdown the reactor and take corrective action to isolate the leak.	1. Describe how to detect minor and major primary coolant heat exchanger leaks. 2. Scram the reactor. 3. Determine that the reactor is shutdown. 4. Isolate the leaking cooler. 5. Complete secondary water isolation system procedure. 6. Notify appropriate people.

COURSE: Quarterly Retraining

UNIT: Reactor Operators and Shift Supervisors

MODULE: Emergency Procedures

TASK: State when the poison water system must be used.

PERFORMANCE OBJECTIVE

Describe the conditions under which the poison water system must be used.

ENABLING OBJECTIVES	**CRITERION REFERENCE MEASURE**
The student must be able to:	**The Student Did:**
Describe the conditions under which the poison water system must be used.	1. Stated that the poison water system must be used if in the judgment of the shift supervisor, it is needed to assure the reactor will stay subcritical (failure of control rods to scram). 2. If a situation exists which will cause light water flooding of the reactor.

COURSE: Quarterly Retraining

UNIT: Reactor Operators and Shift Supervisors

MODULE: Emergency Procedures

TASK: Take corrective action during a loss of AC power

PERFORMANCE OBJECTIVE

Given a loss of AC power which causes a reactor scram the trainee will use the Basic Emergency Shutdown Procedure and take corrective action.

ENABLING OBJECTIVES	**CRITERION REFERENCE MEASURE**
The student must be able to:	**The Student Did:**
Recognize the reactor scram was caused by a loss of AC power and use the Basic Emergency Shutdown Procedure and take corrective action.	1. Determine that reactor is shutdown. 1a. Check to see that at least 5 main rods are full in. 1b. Check to see the power is dropping and period is negative. 1c. Check to see that shutdown flow is established. 2. Establish secondary coolant flow to shutdown cooler. 3. Check to see emergency generator is running. 4. After power is restored to normal return plant to normal conditions.

COURSE: Quarterly Retraining

UNIT: Reactor Operators and Shift Supervisors

MODULE: Emergency Procedures

TASK: Take corrective action during a momentary loss of AC power

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PERFORMANCE OBJECTIVE

Given a momentary loss of power which causes a reactor scram the trainee will use the Basic Emergency Shutdown Procedure and take corrective action.

ENABLING OBJECTIVES	CRITERION REFERENCE MEASURE
The student must be able to:	**The Student Did:**
Recognize the reactor scram caused by a momentary loss of power. Use the BESP. Check all electrical breakers and associated equipment for proper operation. Restart the rector.	1. Check power recorder for dip in power to verify cause of event. 2. Determine that reactor is shutdown. 3. Assure adequate core cooling. 4. Check electric breakers and associated equipment for proper operation. 5. Restart reactor.

COURSE: Quarterly Retraining

UNIT: Reactor Operators and Shift Supervisors

MODULE: Emergency Procedures

TASK: Take corrective action after recognizing a primary system leak

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PERFORMANCE OBJECTIVE

Given a primary system leak the trainee will use the Basic Emergency Shutdown Procedure and take corrective action.

Typical Examples:

(a) flange leak
(b) weld leak
(c) control rod drive shaft leak
(d) pump shaft leak

ENABLING OBJECTIVES	CRITERION REFERENCE MEASURE
The student must be able to:	**The Student Did:**
Detect leak in the primary coolant system, use the BESP. Depressurize the reactor, locate the leak. Take corrective action to repair the leak.	1. Detect leak. 2. Scram the reactor. 3. Determine reactor is shutdown. 4. Assure adequate core cooling. 5. Depressurize reactor. 6. Locate and/or repair leak. 7. After repairs are made restart reactor.

COURSE: Quarterly Retraining

UNIT: Reactor Operators and Shift Supervisors

MODULE: Emergency Procedures

TASK: After a reactor scram caused by personnel error take corrective action

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PERFORMANCE OBJECTIVE

Given a personnel error that caused a reactor scram the trainee will use the Basic Emergency Shutdown Procedure and take appropriate corrective action.

(a) accidental hitting of scram button
(b) accidental scram during instrument calibration

ENABLING OBJECTIVES	CRITERION REFERENCE MEASURE
The student must be able to:	**The Student Did:**
Recognize the cause of the reactor scram, determine that the reactor is shutdown. Correct the condition that used the scram and restart the reactor.	1. Recognize the cause of the accidental scram. 2. Determine the reactor is shutdown. 3. Assure adequate core cooling. 4. Correct condition. 5. Restart reactor.

COURSE: Quarterly Retraining

UNIT: Reactor Operators and Shift Supervisors

MODULE: Emergency Procedures

TASK: After a loss of cold neutron facility moderator coolant take corrective action

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PERFORMANCE OBJECTIVE

Given a loss of cold neutron facility moderator coolant which causes a reactor setback the trainee will shutdown the reactor using the Basic Emergency Shutdown Procedure and take corrective action.

ENABLING OBJECTIVES	CRITERION REFERENCE MEASURE
The student must be able to:	**The Student Did:**
Recognize the reactor setback caused by the loss of moderator coolant. Shutdown the reactor using the BESP. Call in CNF technicians to correct the trouble and restart reactor.	1. Recognize setback condition. 2. Scram the reactor. 3. Determine reactor is shutdown. 4. Assure adequate core cooling. 5. Notify CNF technicians to come in a correct trouble. 6. Restart reactor.

COURSE: Quarterly Retraining

UNIT: Reactor Operators and Shift Supervisors

MODULE: Emergency Procedures

TASK: After a failure of a secondary water pump take corrective action

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PERFORMANCE OBJECTIVE

Given a failure of a secondary water pump motor which causes a loss of secondary water pump flow and a reactor setback due to high core inlet temperature. The trainee will shutdown the reactor using the BESP and take corrective action.

ENABLING OBJECTIVES	CRITERION REFERENCE MEASURE
The student must be able to:	**The Student Did:**
Recognize the reactor setback caused by high core inlet temperature and the loss of a secondary cooling water pump. Shutdown the rector using the BESP. Lock out the breaker on the failed pump motor. Check other plant breakers for proper position. Start another cooling water pump. Restart reactor.	1. Recognize setback condition. 2. Scram the reactor. 3. Determine reactor is shutdown. 4. Assure adequate core cooling. 5. Locate failed cooling water pump motor. 6. Lock out pump motor breaker. 7. Check breakers for proper position. 8. Start another cooling water pump. 9. Restart reactor.

COURSE: Quarterly Retraining

UNIT: Reactor Operators and Shift Supervisors

MODULE: Emergency Procedures

TASK: After a primary pump motor failure take corrective action

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PERFORMANCE OBJECTIVE

Given a failure of a primary pump motor which causes the incoming breakers to trip, a reactor scram due to low primary flow the trainee will shutdown the reactor using the BESP and take corrective action.

ENABLING OBJECTIVES	CRITERION REFERENCE MEASURE
The student must be able to:	**The Student Did:**
Recognize the reactor scram due to a failure of the primary pump. Assure the reactor is shutdown using the BESP. Establish adequate shutdown cooling, lock out the breaker on failed pump motor. Re-establish normal AC power by closing the incoming feeders. Notify Operations Group Leader.	1. Recognize condition causing scram. 2. Determine that the reactor is shutdown. 3. Check to see that shutdown pump "ON". 4. Establish secondary coolant flow to shutdown cooler. 5. Check to see emergency generator "ON". 6. Re-establish AC power. 7. Lock out breaker on failed pump motor. 8. Notify Operations Group Leader.

COURSE: Quarterly Retraining

UNIT: Reactor Operators and Shift Supervisors

MODULE: Emergency Procedures

TASK: After unusual vibration in the primary coolant system take corrective action

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PERFORMANCE OBJECTIVE

Given loose parts or unusual vibration in the primary cooling system reactor vessel, primary pump motors or primary heat exchangers the trainee will shutdown reactor using the Basic Emergency Shutdown Procedure. Shutdown the primary pumps and establish normal shutdown mode and notify Operations Group Leader.

ENABLING OBJECTIVES	**CRITERION REFERENCE MEASURE**
The student must be able to:	**The Student Did:**
Recognize unusual vibration in the primary coolant system, describe the hazards associated with unusual vibration, shutdown the primary pumps and establish normal shutdown mode. Notify Operations Group Leader.	1. Diagnose unusual vibration. 2. Describe the hazards. 3. Shutdown the reactor using the BESP. 4. Shutdown the primary cooling pumps. 5. Establish shutdown cooling in normal shutdown mode. 6. Notify Operations Group Leader.

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COURSE: Quarterly Retraining

UNIT: Reactor Operators and Shift Supervisors

MODULE: Emergency Procedures

TASK: After recognizing a substantial leak in the secondary cooling water system take corrective action

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PERFORMANCE OBJECTIVE

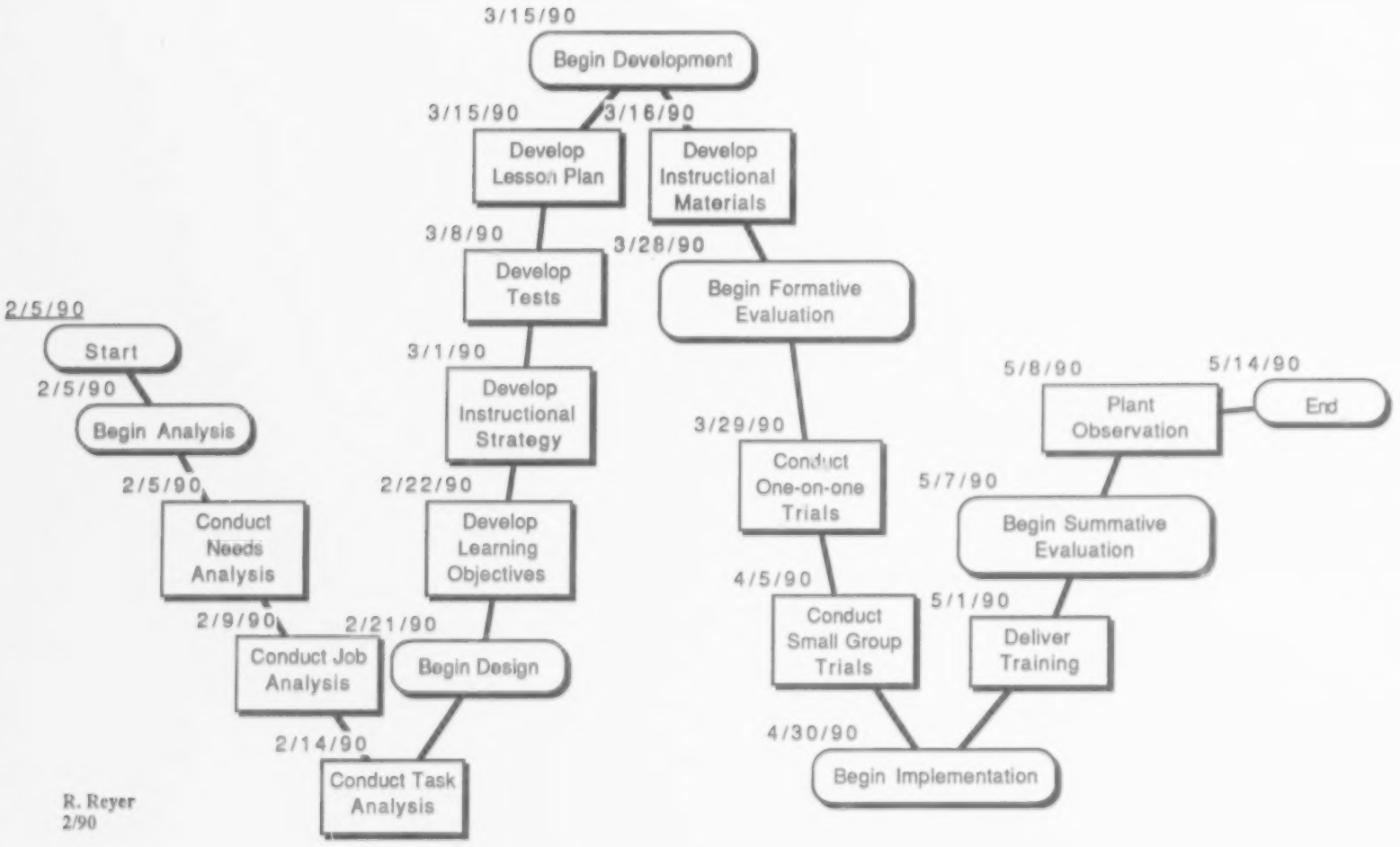
Given a large leak in the secondary water cooling system the trainee will shutdown the reactor using the BESP and inform the necessary people.

ENABLING OBJECTIVES	CRITERION REFERENCE MEASURE
The student must be able to:	**The Student Did:**
Recognize a leak in the secondary cooling water system. Shut the reactor using the BESP. Locate and or repair leak. Inform necessary people.	1. Detect leak. 2. Scram reactor. 3. Determine reactor is shutdown. 4. Assure adequate core cooling. 5. Locate and or repair leak. 6. Inform management. 7. After repairs are made restart reactor.

APPENDIX B

PROJECT SCHEDULE

Emergency Procedure Training
Development Plan



R. Reyer
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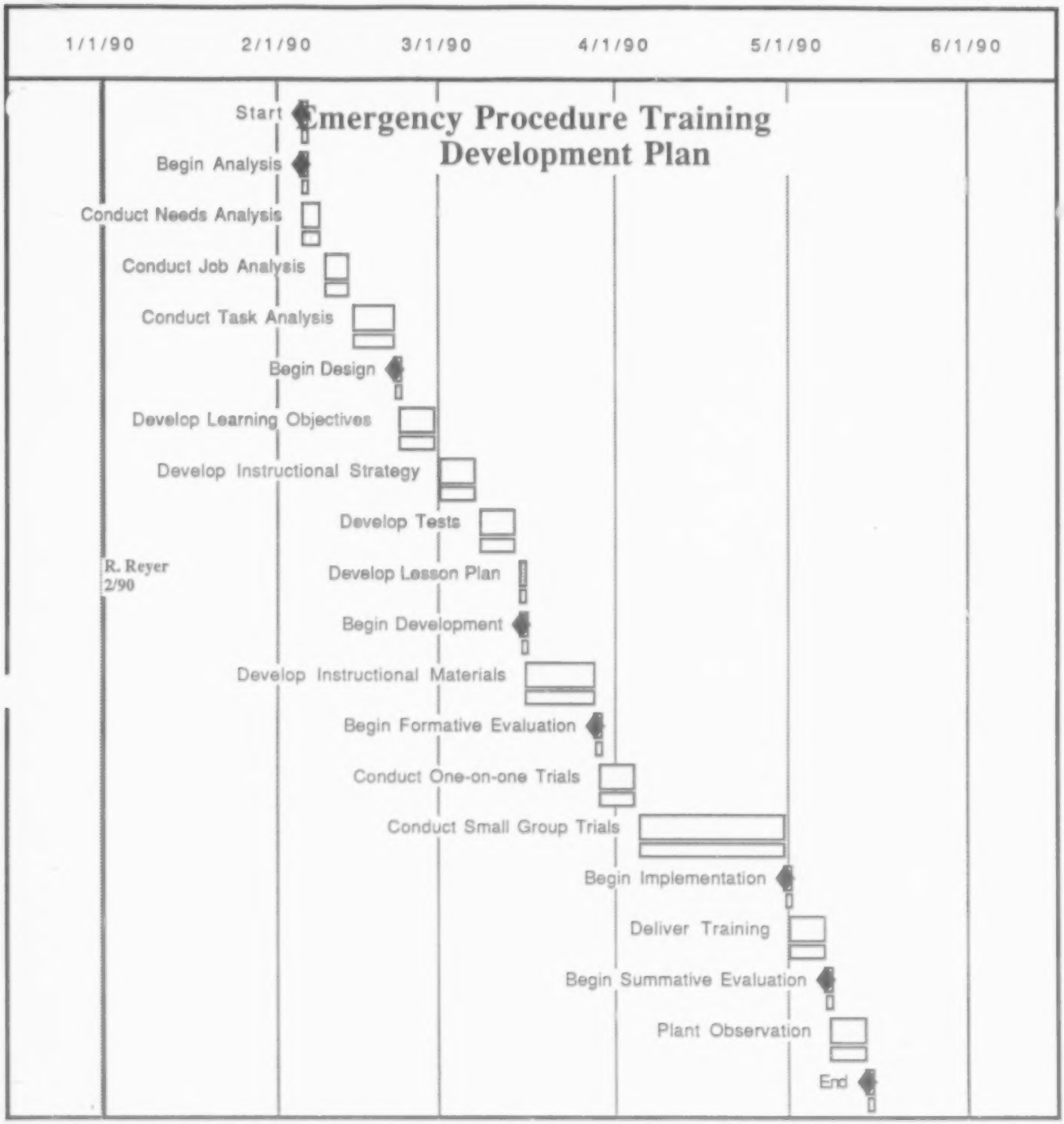
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Emergency Procedure Training
Development Plan
Start
Begin Analysis
Conduct Needs Analysis
Conduct Job Analysis
Conduct Task Analysis
Begin Design
Develop Learning Objectives
Develop Instructional Strategy
Develop Tests
Develop Lesson Plan
Begin Development
Develop Instructional Materials
Begin Formative Evaluation
Conduct One-on-one Trials
Conduct Small Group Trials
Begin Implementation
Deliver Training
Begin Summative Evaluation
Plant Observation
End
R. Reyer
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APPENDIX C

LEARNING OBJECTIVES

BASIC EMERGENCY SHUTDOWN PROCEDURE

Learning Objectives: Upon satisfactory completion of this section, the trainee will be able to:

1. Describe the events which indicate that an emergency reactor shutdown has occurred, and the indications by which the reactor operator can judge that the reactor is safely shut down and subcritical.

2. Explain the conditions under which the reactor operator must manually shut down the reactor.

3. Describe the primary intent of the Basic Emergency Shutdown Procedure.

4. Describe the conditions which determine that the reactor is in fact shut down following an automatic or manual trip.

5. Describe the actions which are taken if the reactor is not subcritical, or if light water flooding of the core occurs.

6. Discuss the actions taken and the factors to consider if the reactor is subcritical but less than five main control rods are fully inserted.

7. Describe the action taken if there is an indication of a primary-to-secondary leak in a primary, shutdown, or experimental facilities cooler.

8. Discuss the methods for determining that primary-to-secondary leakage exists and the consequences of such leaks if not properly isolated.

9. Describe the methods to ensure that adequate core cooling exists and the preferred methods for heat removal if adequate vessel coolant level exists.

10. Explain at what vessel level the primary pump pony motors should be stopped and the vessel steam vent valves opened, and the reasons for these actions.

11. Discuss the actions to be considered following an emergency shutdown after the reactor has been placed in a subcritical condition with all leakage paths isolated and adequate core cooling established.

12. Describe the restrictions placed on the dumping of the poison water into the reactor vessel.

BNL EMERGENCY RESPONSE PLAN

LEARNING OBJECTIVES: Upon satisfactory completion of this section, the trainee will be able to:

1. Describe the Warning Signal and the Evacuation Signal.

2. Describe the methods of actuation of the Warning Signal and the Evacuation Signal.

3. Discuss the expected response of all building occupants to the Warning Signal and the Evacuation Signal.

4. Identify the Local Emergency Coordinator and Laboratory Emergency Supervisor and list their responsibilities.

5. Identify the Traffic Controller and discuss his responsibilities.

6. Identify the HFBR Local Emergency Forces and explain their response to emergency signals.

7. Describe the Technical Support Center and Operations Support Center and explain their function during emergencies.

8. State the five classes of emergencies in ascending order and discuss examples of initiating conditions for each class.

9. Discuss the reasons for the building re-entry guidelines.

10. Discuss the duties of the shift supervisor if a BNL evacuation occurs or is imminent because of hazards not associated with the HFBR.

11. State the relationship between the BNL Emergency Plan, the HFBR Local Emergency Plan, and the HFBR Building Evacuation Procedures.

12. State what forces make up the Laboratory Emergency Forces.

13. State the people assigned to the Emergency Operations Facility and their major functions.

14. State the site emergency signals.

15. Describe how to initiate the BNL emergency plan in response to a personnel or other emergency.

FLOW REVERSAL PROCEDURES

LEARNING OBJECTIVES: Upon satisfactory completion of this section, the trainee will be able to:

1. Describe the conditions under which flow reversal occurs.

2. Explain why the pony motors must be shut down if the vessel level drops to 177".

3. State the major concern to prevent fuel element damage following the depressurization and onset of bulk boiling on loss of all forced flow cooling.

4. Describe the three factors which determine the time required for all the water in the reactor vessel to reach the boiling point following initiation of natural circulation cooling.

5. Discuss the reasons why the maximum reactor vessel pressure should be limited to 12 psig during natural circulation cooling, and why it may not be possible to maintain this limit.

6. Identify the cooler which is preferred to use as a condenser for the steam produced by boiling, and discuss the reasons why.

7. Describe the four methods for supplying secondary water to the shutdown cooler during natural circulation cooling, in order of preference.

8. State the limit on secondary water flow rate to the shutdown cooler when used as a condenser, and explain the reasons for the limit.

9. State the limit on secondary water pressure at the inlet to the shutdown cooler during natural circulation cooling, and explain why this limit is necessary.

10. Describe the actions necessary to establish the steam flow path when using the shutdown cooler as a condenser during natural circulation cooling.

11. Describe the two methods for supplying secondary water to a primary cooler when it is being used as a condenser.

12. Describe the indications which assure that the cooler which is set up to condense steam during natural circulation is properly functioning.

13. State the minimum vessel coolant level that must be maintained during natural circulation cooling.

14. Discuss the sources of heavy water that is used for makeup to the reactor vessel during natural circulation cooling.

15. Describe the authorization that must be obtained before the reactor may be started up following natural circulation cooling.

IN-CORE FUEL CLADDING FAILURE PROCEDURE

LEARNING OBJECTIVES: Upon satisfactory completion of this section, the trainee will be able to:

1. Describe the sources of fission product contamination of the primary coolant system.

2. List the key instrument systems which would indicate a fuel cladding failure, and indicate which provide alarm functions only and which will cause a reactor shutdown when tripped.

3. Indicate the most likely time that a fuel cladding failure would occur, and discuss the reasons.

4. Discuss the conditions that should be monitored by the reactor operating crew for early indications of abnormal conditions leading to fuel cladding failure.

5. Indicate the relative sensitivity of the instruments which detect fuel cladding failure, and discuss the delay times associated with the instruments.

6. Describe the two major concerns in the event of an In-Core Fuel Cladding Failure Procedure.

7. Discuss how the first few steps of the In-Core Fuel Cladding Failure Procedure addresses these concerns described in 6. above.

8. Explain why it is necessary to quickly stop the addition of nitric acid into the primary coolant when a fuel cladding failure occurs.

9. Explain why the vessel pressure will slowly increase over time even though the cover gas inlet has been closed off.

10. State the method for initiating the evacuation of non-essential personnel from the reactor building.

11. Describe the additional steps that are taken to assure that all cover gas purge paths are isolated.

12. Describe the action taken with the following reactor systems and equipment during the performance of the in-core fuel cladding failure procedure:
    a. the primary purification system.
    b. the pump seal drain tank vent system.
    c. the primary acidification system.
    d. the cover gas charcoal filter that is in service.
    e. the Exit Air Bypass Filter Facility valves.
    f. vessel cover gas system.
    g. primary water sampling system.

13. State the level in d/m of radioiodine activity in a primary coolant sample that would require declaring:
    a. an unusual event.
    b. an alert.

14. Discuss the concern for the liquid level in the "F" half of the F/D Waste Tank during this emergency.

15. Discuss the application of the Normal Reactor Shutdown Procedure after the emergency condition has been stabilized.

COMPRESSED AIR FAILURE PROCEDURE

LEARNING OBJECTIVES: Upon satisfactory completion of this section, the trainee will be able to:

1. State the two major compressed air systems associated with the HFBR, and the common mode failure that would affect them both.

2. Explain the affect of a loss of reactor building compressed air on the following reactor equipment:

   a. The reactor depressurization valve HCe-102.
   b. The reactor setback system.
   c. The building inlet air valves IN,2N,1S,2S. and the condensate drain valves on the building air handlers.
   d. The building exhaust bypass valves ABV-1 and 2.
   e. The building exhaust blower discharge dampers.
   f. All pneumatic process instrumentation in the control room.
   g. Break tank level control valve LC-306.
   h. All air lock control systems.
   i. Local level indication for D_2O Storage Tanks FA101 and FA102.
   j. Local level indication for Liquid Waste Tank FA305.

3. Describe how the following remotely operated components, used for control and system isolation, fail during a loss of compressed air:

   a. Dump Control Valve DCV-1.
   b. Secondary Water Return Valves WR-1,WR-2 and WR-3.
   c. Secondary Water Supply Valve WS-3.
   d. Primary Pump Suction Valves HC-102A&B.
   e. Primary System Control Valves HCV-101A and B.
   f. Experimental Facilities Cooling System Drain Valve HC-101a.
   g. Shutdown Pumps Low Flow Control Valve LFCV-101.
   h. Shutdown Cooler EA-103 Secondary Water Return to Sump Valve WR14.

4. Explain how the following pump house components will respond to a loss of pump house compressed air:

   a. Cooling tower Basin Makeup Control Valves MCV-1 and 2.
   b. Conductivity Control Valve CCV-1.
   c. Secondary Water Temperature Control Valve TCV-1.
   d. Secondary Water System Overpressure Control Valve PCV-1.

5. Describe the four main reasons or malfunctions that could cause a loss of compressed air.

6. State the primary concern of the reactor operators during a compressed air failure.

7. Discuss the actions taken if a compressed air failure is caused by a break or rupture in a compressed air line.

8. Describe what is done if the reactor building or pumphouse air dryer fails and causes a loss of compressed air.

9. Describe the utilization of backup air compressor GB-301C.

CORRECTIVE AND EMERGENCY PROCEDURES DURING FUEL DISCHARGING OPERATIONS

LEARNING OBJECTIVES: Upon satisfactory completion of this section, the trainee will be able to:

1. State the five (5) most likely failures of fuel discharging equipment during fuel discharging operations.

2. Describe the consequences of each of the failures referred to in 1. above.

3. Discuss the major area of concern during fuel discharging operations that make it imperative to perform corrective actions on failed equipment as quickly as possible.

4. Describe the corrective actions taken in response to each of the failures referred to in 1. above.

5. Describe the condition which results in a fuel discharging emergency.

6. State the time limit on the shift's efforts to free a stuck spent fuel element before they must evacuate the building.

7. Describe the three actions that the shift must take before evacuating the building during a fuel discharging emergency.

8. Describe the route that building evacuees should take during a fuel discharging emergency.

9. State which class of emergency is declared when a fuel discharging emergency occurs.

10. Describe the predicted time period between loss of cooling and beginning of cladding melt for a stuck fuel element, and discuss the factors which can have an affect on this time period.

11. Discuss the areas in which high radiation levels will occur following fuel element damage resulting from a fuel discharging emergency.

IN-VESSEL EXPERIMENTAL FACILITY THIMBLE LEAK PROCEDURE

LEARNING OBJECTIVES: Upon satisfactory completion of this section, the trainee will be able to:

1. Describe the indications of an in-vessel vertical irradiation thimble leak.

2. State the two major primary system conditions which have an effect on the symptoms of a thimble leak.

3. Describe the indications of an in-vessel thimble leak at a level below the vessel water level with the vessel pressurized, and discuss the reasons for these indications.

4. Describe the indications of an in-vessel thimble leak with the vessel depressurized, and discuss the reasons for these indications.

5. Explain how a slow leak in an in-vessel thimble during reactor operation would be detected.

6. Describe the indications of a leak in a vertical irradiation thimble outside of the reactor vessel.

7. Give the reasons why the initial step in the experimental facility thimble leak procedure is to shut down the reactor using the BESP.

8. Discuss the subsequent steps of the leak procedure following reactor shutdown to put the plant in a safe, stable condition.

9. Describe the steps taken to determine the location of an in-vessel experimental facility thimble leak.

10. Discuss the long-term programmatic effects of an in-core thimble leak.

APPENDIX D

COGNITIVE SUBSKILL PERFORMANCE OBJECTIVE AND TEST ITEMS

Subskill	Performance Objective	Test Item
Define "Out of Limit Cond"	Given a "Out of Limit Cond" the trainee shall be able to state the definition in his own words.	Define "Out of Limit Cond"
State what action you would take if an "Out of Limit Condition" was found at the Reactor.	Given an "Out of limit Cond" at the Reactor, the trainee must be able to state the action to be taken and describe the reason for taking the action.	Describe the action that must be taken when an "Out of Limit Condition" is found at the Reactor. Explain the reasons for taking the action.
Recognize an "Out of Limit Condition"	Given various reactor conds. the trainee must be able to state the limits of operat. and name those that are "Out of Limit."	State the operating limit for the following conditions: reactor powerlevel, reactor inlet temp, and vessel level.
After a "Scram" describe what constitutes reactor shutdown.	Given a reactor "Scram" the trainee should be able to explain the conditions that should occur for the reactor to be considered to be in a safe shutdown condition.	After a Reactor "Scram" explain the conditions that should occur for the Reactor to be considered to be in a safe shutdown condition.
State what action you would take if an "unsafe" condition was found at the Reactor.	Given an "unsafe" condition such as a fire, a security problem, etc. the trainee must describe the actions to be taken.	State the action that must be taken when an usafe condition is found at the reactor.

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Subskill	Performance Objective	Test Item
Name the Instruments in control room that should be observed to determine the shutdown condition of the Reactor.	Given a reactor scram the trainee must be able to list the instruments in the control rm. which would be used to determ. the shutdown condition of the Reactor.	List The Instruments in the control room which would be used to determine the shutdown condition of the reactor.
Explain the need for 5 main control rods to drive "full in" after a "Scram."	Given a "scram" the trainee must be able to explain the need for at least 5 main cont. rods to be in the full "in position.'	After a "Scram" explain the need for at least 5 main control rods to be in the full in position.
Explain the action to take if less than 5 main control rods are found "full in" after a "scram"	Given a reactor "scram" with less than 5 main control rods driven full in, the trainee will explain what action to take.	After a "scram" with less than five control rods driven full in explain what action to take.
List the instruments in the control room that operate during a power failure.	Given a loss of power, the trainee must be able to: 1. List the instruments in the control room that are fed from the emergency generator. 2. If the emergency generator does not start list the instruments that have individ. batteries.	List the instruments that oper. in the control room after a power failure from the emerg. generator and from batteries if the generator does not start.

Subskill	Performance Objective	Test Item
State when the poison water system must be used.	Given the need to maintain the Reactor in a subcritical state the trainee must be able to explain the conditions when it is necessary to use the poison water system.	Explain the conditions when it would be necessary to use the poison water system to keep the Reactor subcritical.
State how to determine a "scram" was caused by a loss of AC power.	Given a scram caused by a loss of power, the trainee will be able to how to identify the the cause of this event.	Explain how to infer that a "scram" was caused by a loss of AC power.
State the actions to take after a "scram" caused by a loss of AC power.	Given a "scram" caused by a loss of AC power, the trainee must be able to explain what actions to take prior to restarting the Reactor.	Explain the actions to take after a "scram" caused by a loss of AC power prior to restarting the Reactor.
List the methods for detecting leaks in the primary coolant system.	Given a leak of primary coolant the trainee will identify the methods that can be used to detect the leak and explain the sensitivity of each.	List the methods used to detect leaks in the primary coolant system and explain the sensitivity of each.
Outline the danger of leaks in the primary coolant system.	Given leaks in the primary coolant system, the trainee will outline the danger to the following: reactor core, bldg. air activity, contamination levels and D_2O inventory.	Explain the danger of leaks in the primary coolant system with respect to the following: reactor core, bldg. air activity, contamination levels and D_2O inventory.

Subskill	Performance Objective	Test Item
Recognize when a minor D_2O leak requires shutdown of the Reactor.	Given a minor D_2O leak the trainee must be able to identify when it becomes necessary to shutdown the Reactor and take corrective action.	If you discover a minor D_2O leak in the primary coolant system explain the conditions when it would be necessary to shutdown the reactor and take corrective action.
Take corrective action after recognizing a primary system leak that requires shutdown of the Reactor.	Given that the Reactor has been shut down due to a primary system leak, the trainee should be able to explain the corrective action necessary.	After shutdown of the Reactor due to a D_2O leak explain the corrective action to be taken.
Take corrective action after a "scram" caused by personnel error.	Given a "scram" caused by a personnel error, the trainee should explain the actions to be taken prior to restarting the Reactor.	After a "scram" due to a personnel error, explain the actionsyou would take prior to restarting the Reactor.
Recognize a reactor "setback" caused by a loss of Cold Neutron Facility Moderator Coolant.	Given a "setback" caused by a loss of Cold Neutron Facility Coolant, the trainee must explain how to recognize this event and describe the corrective action to be taken	After a "setback" due to a loss of Cold Neutron Facility Moderator Coolant explain how to recognize this event and the corective action to take.

Subskill	Performance Objective	Test Item
Recognize the conditions which would indicate a secondary cooling water pump failure.	Given the failure of a secondary cooling water pump the trainee must be able to describe its effect on primary cooling water temperature and reactivity.	After a loss of a secondary water pump explain its effect on primary water temperature and reactivity.
State the corrective action to take after a secondary cooling water pump failure.	Given the failure of a secondary cooling water pump the trainee must be able to explain how to recognize this event and describe the corrective action necessary.	After a loss of a secondary water pump explain how to recognize this event and the corrective action necessary.
Recognize the conditions which indicate a primary cooling water pump failure.	Given the failure of a primary cooling water pump, the trainee must be able to explain the conditions that will cause a Reactor "scram."	After a loss of a primary cooling water pump explain the conditions that will cause a Reactor "scram."
List the points in the primary coolant system that are monitored for vibration.	Given a list of points that are monitored for vibration in the primary system, the trainee must state the reason for monitoring each point.	State the points that are monitored for vibration in the primary coolant system and the reason for monitoring each point.
State the limits of vibration for each point monitored.	Given each point monitored for vibration in the primary cooling system, the trainee must be able to state the allowable limit	State the allowable limits for vibration for each point monitored in the primary coolant system.

APPENDIX E

SCHEDULE OF CLASSES

BROOKHAVEN NATIONAL LABORATORY

MEMORANDUM

DATE: October 16, 1987

TO: Distribution

FROM: R. J. Reyer RR

SUBJECT: Fourth Quarter HFBR Retraining

The topic for this quarter's retraining program is Emergency Procedures. The following emergency procedures will be covered by classroom lecture.

1. Basic Emergency Shutdown procedure
2. Compressed Air Failure
3. Flow Reversal
4. In-Vessel Experimental Facility Leak
5. In-Core Fuel Cladding Failure
6. Emergency Responses During Fuel Handling
7. BNL Emergency Response Plan

Please study the procedures prior to attending the class lecture. The classroom training will consist of working groups handling problem scenarios using the emergency procedures. A schedule indicating the time that has been designated for the training and the exam will be sent at a later date.

Enclosed also for each procedure is a set of learning objectives in order for you to prepare for the quarterly exam. The examination will cover the material stated in the learning objectives.

Distribution

J. Barkwill
R. Bergoffen
D. Bingham
M. Brooks
O. Colson
M. Davis
C. Diaz
L. Evers
H. Frei
A. Harris
H. Hauptman
R. Hudson
G. Jayne
L. Junker
R. Karol
J. Nelson
M. Niewiarowicz
D. Oldham
D. Ports
A. Queirolo
R. Rooks
J. Scott
E. Sierra
D. Stonebridge
R. Tache

1987 FOURTH QUARTER TRAINING SCHEDULE

Name	Class Date	Designated Relief	Exam Date
G. Jayne	November 18	J. Barkwill	November 23
M. Niewiarwicz	"	D. Bingham	"
R. Karol	"	E. Sierra	"
H. Frei	November 25	M. Davis	November 30
R. Rooks	"	D. Bingham	"
L. Junker	"	E. Sierra	"
A. Harris	"		"
J. Nelson	December 2	M. Davis	December 7
O. Colson	"	D. Bingham	"
A. Queirolo	"	E. Sierra	"
C. Diaz	"		"
J. Barkwill	"		"
L. Junker	"		"
R. Tache	December 9	D. Bingham	December 14
L. Evers	"	E. Sierra	"
J. Scott	"		"
D. Ports	"		"
E. Sierra	December 16	None	December 21
D. Bingham	"	"	"
D. Stonebridge	"	"	"
M. Davis	"	"	"
R. Hudson	"	"	"

All classes will be held in the HFBR Lobby Conference Room, Building 750, beginning at 0900.

Note: If you are unable to meet this schedule, please notify A. Queirolo or the Training Group as soon as possible.

APPENDIX F

FLIPCHARTS

CAUSES OF REACTOR SHUTDOWNS

1973 to 1987

	NO. OF EVENTS
CNF-RELATED EVENTS	16
PERSONNEL ERRORS	11
PRIMARY SYSTEM LEAKS	6
FAILURE OF PUMPS	5
LOSS OF INCOMING POWER	5
ELECTRICAL SYSTEM FAILURES	4
ACCIDENTAL SHUTDOWN DURING TESTING OF THE NSS	4
FUEL CLADDING FAILURES	2
SECONDARY WATER SYSTEM PIPE LEAK	2
MISCELLANEOUS	12
TOTAL	67

CAUSES OF REACTOR SHUTDOWNS

1973 to 1987

	NO. OF EVENTS
PERSONNEL ERRORS	11
COVER GAS PRESSURE LOW (DRAINING D_2O)	2
EMERGENCY SECONDARY WATER LINE LEAK	1
REMOVAL OF SETBACK FUSE	1
HALON FIRE SUPPRESSION SYSTEM	1
ACCIDENTAL MANUAL SCRAMS	2
REACTOR PERIOD SCRAM	1
LOSS OF SECONDARY COOLING WATER PUMP	1
REMOVAL OF WRONG FUSE	1
INSTRUMENT TECH. WORKING ON PdRa-101	1

CAUSES OF REACTOR SHUTDOWNS

1973 to 1987

	NO. OF EVENTS
FAILURE OF PUMPS	5
BIOLOGICAL SHIELD PUMP	1
THERMAL SHIELD PUMP	1
ABNORMAL VIBRATION PONY MOTORS	1
PRIMARY PUMP BEARING FAILURE	1
AMPS HIGH PRIMARY PUMP A	1

	NO. OF EVENTS
PRIMARY SYSTEM LEAKS	6
PERISCOPE FLANGE GASKET LEAK	1
PRIMARY PUMP SEAL LEAKS	3
RESISTANCE THERMOMETER WELL	1
LEAKAGE OF CONTROL ROD SEALS	1

CAUSES OF REACTOR SHUTDOWNS

1973 to 1987

	NO. OF EVENTS
ELECTRICAL FAILURES	4
FAILURE OF GA-101A PUMP BREAKER	1
SHUTDOWN PUMP RUNNING ON BATTERY POWER	1
PRIMARY PUMP GA-101B MOTOR FAILURE	1
NO. 3 COOLING WATER PUMP SHORTED	1

CAUSES OF REACTOR SHUTDOWNS

1973 to 1987

	NO. OF EVENTS
MISCELLANEOUS FAILURES	12
SHUTDOWN TO CORRECT DESIGN DEFICIENCY	1
ABNORMAL VESSEL NOISE (ANTI-CRITICAL GRID)	1
LOW FLOW VERTICAL FACILITY V-15 (BOILING)	1
MANUAL SCRAM TO INVESTIGATE FIRE	1
AMPS HIGH PRIMARY PUMPS	1
SCRAM FROM NSS SYSTEM	1
NSS COMPONENT FAILURE	1
CONTACT PROBLEM ON MANUAL SCRAM BUTTON	1
SECONDARY COOLING WATER FLOW LOST TO SHUTDOWN COOLER	1
CORE INLET TEMP. TRIP (SINGLE LOOP MODE)	2
AUXILIARY CONTROL ROD FAILURE TO DRIVE	1

APPENDIX G

LESSON PLAN

TRAINER PREPARATION SHEET

COURSE TITLE: QUARTERLY TRAINING EMERGENCY PROCEDURES

LESSON TITLE: RETRAINING EMERGENCY PROCEDURES

TIME PERIOD: 6 HOURS

REFERENCES:

- OPM SECTION 3.1 BASIC EMERGENCY SHUTDOWN PROCEDURE
- OPM SECTION 3.5 FLOW REVERSAL PROCEDURE
- OPM SECTION 3.7 PROCEDURE IN THE EVENT OF AN IN-CORE FUEL CLADDING FAILURE
- OPM SECTION 3.10 COMPRESSED AIR FAILURE PROCEDURES
- OPM SECTION 3.11 CORRECTIVE AND EMERGENCY PROCEDURES DURING FUEL HANDLING OPERATION
- OPM SECTION 3.12 IN VESSEL EXPERIMENTAL FACILITY THIMBLE LEAK PROCEDURES
- BNL EMERGENCY RESPONSE PLAN

OBJECTIVES:

1. OVERVIEW OF HISTORY OF OCCURRENCES CAUSING REACTOR SHUTDOWNS (1973 TO PRESENT)
2. SELF STUDY OF EMERGENCY PROCEDURES (SEE ATTACHED LEARNING OBJECTIVES)
3. CLASSROOM PROBLEM SITUATIONS USING EMERGENCY PROCEDURES (SEE ATTACHED)

INSTRUCTIONAL AIDS:

COPY OF PROCEDURES
OVERHEAD PROJECTOR
BLACKBOARD

TRAINEE PREPARATION:

SELF STUDY OF EMERGENCY PROCEDURES

98

PRESENTATION METHOD:

LECTURE AND PROBLEM SOLVING WORK IN SMALL GROUPS

EVALUATION:

EXAMINATION WRITTEN

DISCUSSION POINTS	INSTRUCTOR/STUDENT ACTIVITY
1. OPENING REMARKS	Describe a scram I have experienced. Ask each member of group to describe a scram or event they were involved with that resulted in a shutdown. As an alternate ask if people were involved when a decision was made to shutdown the reactor because something was wrong. Ask them to describe the event and how it was handled.
2. PRESENT OVERVIEW OF LESSON	Lecture by Instructor
a. Causes of Reactor Shutdowns (15 years)	
b. Problem Scenarios	
c. Self Study Learning Objectives for Examination	
3. DISCUSSION CAUSES OF REACTOR SHUTDOWNS DURING LAST 15 YEARS	Ask Students to list what events caused the greatest amount of shutdowns. List on blackboard. Ask students for details of the event and how they would have handled the situation using the Basic Emergency Shutdown procedure.
4. DISCUSS VARIOUS CATEGORIES OF SHUTDOWNS	
o CNF-Related Events	Discuss major cause loss of moderator chamber cooling
o Personnel Errors	Later see sheet 4
o Primary System Leaks	Later see sheet 5
o Failure of Pumps	Later see sheet 5
o Loss of Incoming Power	Discuss events that have occurred
o Electrical System Failures	Later see sheet 6
o Accidental Shutdown During Testing of NSSS	Discuss events that have occurred
o Fuel Cladding Failures (76-1, 77-1)	Discuss data from UORs
o Secondary Water System Pipe Leak	Discuss recent problems with piping
o Miscellaneous	Discuss later sheet 7

DISCUSSION POINTS	INSTRUCTOR/STUDENT ACTIVITY
5. DISCUSSION OF PERSONNEL ERRORS	Ask group what were the type of errors made. Write on blackboard. After list is complete show flipchart 2 and compare with list.
o Cover Gas Pressure Low Draining (83-3)	
o Emergency Secondary Water Line Leak (84-12)	Discuss each category. Ask people to explain event if they can recall it. Ask group about procedural changes that were made as a result of the UORs.
o Halon Fire Suppression System (86-7)	
o Reactor Period Scram (83-5)	
o Loss of Secondary Cooling Pumps (80-4)	
o Removal of Wrong Fuse	
6. DISCUSSION OF FAILURE OF PUMPS	Ask what type of pump failures occurred. Write on blackboard. After list is complete compare with flipchart 3. Question Operators on details and discuss causes as given below:
o Biological Shield Pump (74-8)	
o Thermal Shield Pump (75-1)	Caused setback
o Abnormal Vibration Pony Motors (79-6)	Failed Thrust Bearing
o Primary Pump Bearing Failure (80-7)	Open Circuit in Motor Leads Intermittent Seizes of Pony Motor Clutches Upper Radial Bearing
o AMPS High Primary Pump A (81-15)	GA-101B Faulty Trip in primary pump Current Trip
7. DISCUSSION OF PRIMARY SYSTEM LEAKS	Ask what type of leaks occurred. After list is complete compare with flipchart 3 and discuss causes.
o Periscope Flange Leak (73-14)	
o Resistance Thermometer Well (74-1)	Replaced Gasket Type Remade new well from stock
o Primary Pump Seal Leaks	Replacement due to wear

DISCUSSION POINTS	INSTRUCTOR/STUDENT ACTIVITY
8. ELECTRICAL FAILURES	Ask what type of electrical equipment failures occurred. Write on blackboard. After list is complete compare with flipchart 4. Question operators on details and discuss causes as given below:
o Failure of GA-101A Pump Breaker (78-4)	Breaker failed during starting of pump
o Primary Pump GA101B Motor Failure (84-11)	Two of three motor leads failed. How amp trip occurred.
o No. 3 Cooling Water Pump Motor Shorted (81-9)	2400 Pump house feeder breaker tripped
o Shutdown Pump Running on Battery Power	EMCC rectifier lost power causing pump to run on battery
9. MISC FAILURES	Show flipchart No. 5 and discuss each event. Ask operators to recall each.
10. PROBLEM SCENARIOS	Break group up into groups of two or three. Appoint leader to arrive at group solution using procedures. Have each leader present solution. Have other groups critique or add to solution.
o Reactor Scram only three rods go in	
o Scram occurs during draining vessel	
o Fuel cladding failure	
o Primary system rupture	
o Loss of power and Emergency generator fails to start	
o Small Leak Event	

APPENDIX H

PROBLEM SCENARIOS

PROBLEM SCENARIO #1

At 60 MW operation, an instrument technician causes a scram while working on the Nuclear Safety System. The reactor scrams but only three rods drop in the reactor. What action do you take?

1. How do you determine the reactor is shut down?

2. If a power failure occurred and the AC generator did not start, what instruments could be used to determine if the reactor is shutdown?

PROBLEM SCENARIO #2

At 60 MW operation, an operator was dispatched to drain some water out of the vessel to FA-101. During the draining process, a rapid drop in level and a reactor scram on low cover gas pressure occurs. What action would you take?

1. Why did the reactor scram on low cover gas pressure?

2. If the reactor vessel dropped below 177" what would the consequences be and what actions would you take?

PROBLEM #3

During reactor startup after reaching 60 MW, a large vibration occurs in the reactor vessel. Suddenly, the FCF monitors scram the reactor and go off scale. Area radiation monitor alarm occurs. Levels on reactor top, and greenhouse are off scale. Describe the actions you would take.

PROBLEM SCENARIO #4

During operation, suddenly, the liquid level drops to below the bubbler tube inlet 171". The reactor is scrammed and all pumps are shutdown. Since a resin bed was replaced this shutdown, you suspect a coniseal joint gave way. Describe the actions you would take.

PROBLEM SCENARIO #5

At 60 MW operation, a loss of LILCO AC power occurs and the emergency generator fails to start.

1. How is the reactor core cooled during these conditions?

2. The power outage has continued for eight hours and the emergency generator has still failed to start.

   a. What procedure do you use to cool the reactor during this condition?

   b. How do you know that steam condensing is taking place?

   c. What do you expect would be happening to the reactor vessel pressure during the use of this procedure?

d. What problems might you expect to experience with the use of flow reversal?

e. What would you do if these problems occurred?

PROBLEM SCENARIO #6

At 60 MW operation, a D_2O leak is discovered by visual observation to be a leak from one of the core differential pressure transmitter lines. The leak is about 15 drops per minute. What action would you take?

APPENDIX I

QUESTION POOL

BASIC EMERGENCY SHUTDOWN PROCEDURE

Q1. What guidelines do you follow that determine when the Basic Emergency Shutdown Procedure must be initiated?

(3)

A1. Whenever an unsafe operating condition develops (out-of-limit condition that cannot be corrected immediately).

Q2. How would you determine that the reactor is shutdown after using the Basic Emergency Shutdown Procedure?

(4)

A2.
a. Control rod indicator and limit lights - at least five main control rods full-in.
b. Nuclear power instruments (Ch 4, 6) - power drops to a few MW, period negative.
c. Primary water temperature should drop if pumps continue to operate. If not, will decay, then rise and then decay again.

Q3. If there has been an AC failure to Building 750 and the emergency generator fails to operate, which of the following will operate and for how long?

(6)

a. Control rod lights
b. Nuclear Channel 9
c. Nuclear Channel 5
d. Nuclear Channel 6
e. FRa-100
f. Pony motor current indicators

A3.
a. two hours
b. 24 hours
c. two hours
d. two hours
e. will not operate
f. two hours

Q4. Assuming a primary-secondary leak has occurred in EA-102, indicate the following: (5)

a. What instrumentation will indicate the leak and what indication will it show?

b. What valving and equipment operational changes, and the sequence of change, would you make in accordance with the procedure, and,

c. Why?

A4. a. RRa-303
In-line tritium monitor
Liquid scintillation system samples
Exp. Fac. expansion tank level rises
Exp. Fac. expansion tank pressure rises to Sec. Sys. Press.
No level or pressure change in reactor vessel

b. Shutdown GA-103A and B
Close pump suction and discharge valves
Close WS-7 and WR-7

c. To isolate the coolers

Q5. What are the three methods of forced circulation cooling of the reactor core in the order of preference? (3)

A5. a. at least one primary pump
b. one shutdown pump
c. at least one primary pump driven by its pony motor

Q6. Assuming a primary-secondary leak has occurred in EA-101A, indicate the following:

(5)

a. What instrumentation will indicate the leak and what indication will it show?

b. What valving and equipment operational changes must be made?

A6. a. RRa-301A - possible rise
H^3 monitor - rise
Secondary sample - rise
Vessel level - drop
Vessel pressure - drop

b. Shutdown GA-101A and GP-101A
Close HCV-101A
Close HCV-301A
Close HC-102A

Q7. What is the minimum time that forced circulation cooling must be maintained following reactor shutdown and why?

(3)

A7. Forced circulation cooling must be maintained for five minutes because natural circulation cooling cannot assure that bulk boiling with possible fuel cladding failure will not occur after shutdown from power levels in excess of 60 MW.

Q8. Why shouldn't the reactor be depressurized below 180 psi when the reactor is above 100 kW?

(2)

A8. The boiling point of D_2O is increased by pressurization. 180 psi will assure that boiling is suppressed with 60 MW of power and minimum allowable flow. Primary pump flow is not needed below 100 kW.

Q9. When the reactor is subcritical but less than five main rods are full-in, why is it necessary to be concerned that it will remain subcritical and how do you assure that it stays subcritical?

(4)

A9. Five main rods full-in assures subcriticality. Without this, decaying xenon may cause the reactor to go supercritical. To assure that it does not, prepare to dump poison water and make partial dump, if necessary.

Q10. Who must be notified of all emergency shutdowns?

(2)

A10. HFBR Operations Group Leader, or, in his absence, the HFBR Plant Manager or RD Manager

Q11. During 60 MW operation, H_2O intrusion could occur if the following happens. (Check correct answers.)

(2)

_ a. rupture of a primary cooler tube
_ b. small leak in a primary cooler tube
_ c. rupture of the reactor vessel

A11. None of the above

Q12. If a primary cooler tube ruptured during 60 MW operation, briefly describe the action you would take.

(4)

A12. Shutdown the reactor using the BESP. Isolate the leaking cooler. Restore liquid level to the reactor vessel and establish shutdown cooling.

Q13. List the possible methods by which light water can enter the primary system. (3)

A13. a. Leaking D_2O cooler (EA-101A and B, EA-103) when primary system depressurized and secondary side of coolers are pressurized.
b. Pouring or flow of JH_2O into an opening in vessel or primary system.
c. Deliberate addition of light water as part of emergency procedures for Primary System Rupture.

Q14. What must be done to counteract the effect of light water flooding? (3)

A14. Add poison water and assure that it remains in the area of the core. The cadmium in the poison water cadmium nitrate solution acts as a neutron absorber; amount available will reduce k_{eff} to 0.9 with 100% H_2O and all rods withdrawn.

Q15a. If leakage occurs in one of the control rod seals, what action would you take? (4)

A15a. Notify the Operations Group Leader and closely monitor leakage.

Q15b. At what point would you consider shutdown of the reactor?

A15b. If leakage was excessive, shutdown the reactor and depressurize.

Q16. How do you assure adequate core cooling during initiation of the Basic Emergency Shutdown Procedure?

(4)

A16. Maintain forced cooling for at least five minutes following reactor shutdown with a primary cooling water pump, a shutdown pump or one primary cooling water pump drive by its pony motor.

Q17. If a D_2O leak was detected in the reactor pit area, what actions would you take?

(4)

A17. Shutdown the reactor, notify the Operations Group Leader and enter the pit area to find and fix the leak.

Q18. What is the primary intent of performing the Basic Emergency Shutdown Procedure?

(3)

A18. Ensure that reactor is placed in a subcritical, shutdown condition with adequate core cooling.

Q19. If after shutdown the reactor is not subcritical, or lightwater flooding occurs, what does the BESP have you do?

(3)

A19. Dump poison water into reactor.

Q20. List the nine basic steps of the BESP.

(6)

A20.
1. Shutdown reactor.
2. Determine reactor shutdown.
3. If reactor is not subcritical, or light water flooding of core occurs, dump the poison water into reactor vessel.
4. If the reactor is subcritical but less than five main rods are full in, make immediate preparations to dump the poison water into reactor and dump same if necessary.
5. If there is indication of a primary to secondary leak in a primary, shutdown or experimental cooler isolate the leaking cooler and shutdown corresponding primary coolant pumps and pony motors.
6. Determine extent of emergency.
7. Assure adequate core cooling.
8. Complete additional emergency procedures.
9. Make appropriate notification.

Q21. Primary pump pony motors shutdown automatically at a reactor vessel level of 177". True or False?

(2)

A21. False

Q22. At what level are primary pump pony motors secured and why do we do this?

(3)

A22. 177" pony motors do not provide enough discharge pressure to produce flow with vessel level lower than 177".

Q23. Describe what would happen to reactivity of the reactor if light water flooding were to occur.

(4)

A23. After first 5% of volume the reactivity in reactor would increase rapidly even with all control rods fully inserted. Neutrons would be thermalized within the core, and poison water would be required to keep reactor subcritical.

FLOW REVERSAL PROCEDURES

Q1. Under what conditions will flow reversal occur?

(3)

A1. Four-out-of-four trips on high-low amperage primary pumps and shutdown pumps and pony motors off.

Q2. Why is flow reversal (natural circulation) necessary under these conditions?

(3)

A2. It allows the core to be cooled by natural circulation when normal primary coolant flow cannot be maintained.

Q3. Describe what happens to the core cooling flow, pony motors and flow reversal valves upon shutdown of the primary pump motors and shutdown pumps.

(2)

A3. Forced cooling flow will continue downward through the core by means of the pony motor driven primary pumps. Flow reversal valves will open at core differential pressure of three psi but forced flow will continue. A portion of the flow, approximately 400 gpm, will bypass the core through the open flow reversal valves.

Q4. Why is a limit of 12 psig placed on vessel pressure during flow reversal and how is it kept below this pressure limit?

(3)

A4. The pressure limit of 14 psig is to keep the vessel temperature limit of 250°F from being exceeded. Since the temperature of the water cannot be easily read, the temperature must be inferred by vessel pressure. The pressure is kept below 14 psig by opening P-102 to maintain pressure at approximately 12 psig.

Q5. Assuming that the four primary pumps have tripped off, what will happen to the core cooling flow upon the loss of both pony motors? What condition would cause you to shut these motors down?

(3)

A5. Forced downward core cooling flow will give way to natural circulation flow upward through the core. The pony motors must be shutdown when the vessel level drops to 177".

Q6. During flow reversal, what is the preferred method of secondary cooling to the HX used as the steam condenser?

(3)

A6. Gravity feed

Q7. If the reactor was operating just prior to flow reversal, what other emergency procedure must be completed first?

(2)

A7. Basic Emergency Shutdown Procedure

Q8. When secondary water is available from the basin, why is there a limit of 100 gpm usage?

(2)

A8. To maintain inventory of the basin so as to provide cooling for about 40 hours.

Q9. By what means might D_2O be lost from the vessel during flow reversal and what must you do to prevent it?

(2)

A9. Through off-gas connections, opening in primary system of vessel, a breach in primary piping or vessel. All off-gas valves, etc., should be closed and sealed. Any breach in piping valved off and isolated, if possible.

Q10. What alternatives are there to gravity flow for the following coolers?

(4)

a. EA-103
b. EA 101A or B

A10. a. EA-103 - Crossconnection flow or domestic water and seismic line;
b. EA-101A or B - Crossconnection flow only.

Q11. What restrictions are there on the secondary water flow to the condensing cooler and why?

(3)

A11. a. Not in excess of 100 gpm for gravity and crossconnection flow.
b. Not in excess of 10 psig during crossconnection or domestic water flow.
c. 10 psig - to reduce or eliminate the probability of H_2O entering the vessel in the event of cooler leak because it would require more than ten psig to push H_2O up to the lowest vessel inlet nozzle. 100 gpm to reduce loss of H_2O inventory in basin due to FA-311 overflow to FA-310.

Q12. Why isn't there a restriction of 10 psig when condensing HX is on gravity feed?

(3)

A12. The ten psig limit probably cannot be reached on gravity feed and also the c/l of this line is about ten feet below the bottom of the vessel outlet line which would preclude any light water from entering the vessel in the event of an HX tube leak.

Q13. To what level must the vessel be drained when using the following coolers as condensers and why?

(4)

a. EA-103
b. EA-101A or B

A13. a. EA-103: Drain to 226" which is just below shutdown loop inlet nozzle. With GA-102A and B Suction Discharge Valves closed, it provides a path of flow for steam to reach cooler while maintaining maximum D_2O inventory in vessel.

b. EA-101A or B: Drain to 162" which is just below primary inlet nozzle. With GA-102A and B and GA-101A and B Suction Valves closed, it provides a path of flow for steam to reach cooler while maintaining maximum D_2O inventory in vessel.

Q14. List three places where you could obtain a supply of D_2O for makeup. Also, list the transfer method.

(3)

A14. a. FA-102 by gravity flow
b. FA-101 by pumping or He pressure to FA-102 and then gravity flow
c. EA-101A and/or B and piping by draining to FA-101 and pumping or He pressure to FA-102 and then gravity flow.

Q15. What must be done before adding condensate to the reactor vessel if the primary-secondary differential pressure limit has been violated in the cooler used to condense steam?

(3)

A15. A D_2O condensate sample must be taken from the station at the base of FA-102 and checked for isotopic purity.

Q16. When returning to normal flow following flow reversal and after the vessel level has been raised to normal, what must be done before starting up primary pumps?

(2)

A16. Take a H_2O sample from the outlet of the cooler that was used as condenser and check for tritium.

Q17. What kind of authorization is necessary prior to startup following flow reversal?

(2)

A17. Written authorization from the Operations Group Leader.

Q18. Under normal flow conditions, what holds the flow reversal valves closed?

(2)

A18. The discharge pressure from any one of the primary or shutdown pumps.

Q19. Indicate which of the following statements are TRUE (T) and which are FALSE (F).

(4)

___ a. When all four primary and shutdown pumps are lost, as long as at least one pony motor is operating, the flow reversal valves will remain closed.
___ b. If all of the flow reversal valves fail to open on demand, fuel burnout will probably occur.
___ c. All four of the flow reversal valves must be operable before the reactor may be operated.
___ d. Normally the shutdown cooler would be used to condense the steam generated in the core during flow reversal.

A19. a. F
b. T
c. T
d. T

Q20. Indicate which of the following statements are TRUE (T) and which are FALSE (F).

(2)

___ a. During flow reversal, the direction of flow of D_2O through the open flow reversal valves would be upward.
___ b. To maintain a minimum level of 80 inches, makeup water should be added to the vessel by gravity flow from FA-102.

A20. a. F
b. T

Q21. What two valves in the shutdown cooling system must be shut as part of the procedure to condense steam in a primary HX?

(2)

A21. GA-102A and B suction valves

Q22. What level should the vessel be drained to in order to condense steam?

(2)

a. EA-101A or B?
b. EA-102?

A22. a. 162"
b. 226"

Q23. The time required for all the water in the reactor vessel to reach the boiling point following initiation of natural circulation cooling depends on three factors. What are these three factors?

(3)

A23. 1. The reactor power prior to the shutdown.
2. The length of time from the shutdown to natural circulation.
3. The vessel level at the time natural circulation begins.

Q24. Flow reversal or natural circulation cooling and using the shutdown cooler as a condenser could occur under the following conditions: (circle correct answer)

(2)

a. Extended power loss to BNL site and emergency generator fails to start.

b. Primary system rupture where the leak cannot be isolated.

c. Shutdown system rupture where the leak cannot be isolated.

d. Leak in the experimental system cooler.

A24. a.

Q25. Describe how to determine that the steam generated in the reactor core is being condensed in the shutdown cooler and flowing by gravity to the storage tank.

(4)

A25. When steam condensing is effective, the reactor pressure should drop close to atmospheric. The loss of liquid level in the reactor vessel should equal the gain in liquid level in FA-101. When this occurs, P102 can be closed.

Q26. During flow reversal, using the shutdown cooler as a condenser, valve P102 must always be open. True or False? Explain your answer.

(4)

A26. False. Once steam condensing is established, P102 must be closed. Leaving this valve open results in a loss of D_2O to the atmosphere.

Q27. During set-up for flow reversal, using the shutdown cooler, the steam pressure starts to rise above the 14 psig. Describe what actions you would take.

(4)

A27. Open the steam vent valves to reduce the pressure and close their valves and P102 after proper condensing action is established.

Q28. During set-up for flow reversal, using the shutdown cooler as a condenser, you find that you are unable to close the bypass valve P101 around the shutdown cooler. The following actions may occur. True or False?

(4)

___ a. Shutdown cooler valve DA6 is periodically opened and closed to drain the condensate to FA-101.

___ b. P102 and the steam vent valves may have to be periodically opened to maintain vessel pressure below 14 psig.

___ c. Liquid level in the reactor vessel can be maintained by adding water initially from FA-102 and later transferring from FA-101.

___ d. An attempt should be made to restore liquid level using all possible sources of D_2O and re-establish cooling as soon as possible.

A28. a. T
b. T
c. T
d. T

Q29. List the three factors that effect the time required for all water in vessel to reach boiling following initiation of natural circulation cooling.

(3)

A29. a. Reactor power prior to shutdown.
b. Length of time between shutdown and initiation of flow reversal.
c. Vessel level at time natural circulation begins.

Q30. If flow reversal occurs because of a primary coolant leak, the primary system rupture procedure OPM 3.4 is implemented for flow reversal. True or False?

(2)

A30. True

Q31. List the four sources of secondary water to shutdown cooler for condensing steam during flow reversal, in their preferred order.

(4)

A31. a. Gravity feed
b. Gross-connect
c. Domestic water
d. Emergency well water

Q32. What would be a good indication that the condenser set up for flow reversal is operating?

(3)

A32. Rapid drop in vessel pressure, temperature rise across secondary side of shutdown cooler should be on the order of 40°F rising level in FA-101.

PROCEDURE IN THE EVENT OF AN IN-CORE FUEL CLADDING FAILURE

Q1. What instruments and/or procedures may be indicative of a fuel cladding failure?
(5)

A1. Cover Gas Monitor - RRa-105
Primary Water Monitor - RRa-100
Exit Gas Activity Monitor - RRa-306
Exit Particulate Activity Monitor - RRa-305
FCF's - RRa-101, 102, 103
EA-101A and B and EA-103 - Containment Monitors
Iodine Grab Sample

Q2. How can the vessel be isolated to prevent a release in the event of fuel cladding failure?
(4)

A2.
a. Close off He inlet controller (PC-106B).
b. Set He outlet controller (PC-106A) to 250 psig.
c. Block closed depressurization valve (HCe-102) with auxiliary air bottle set at 25 psig.
d. Check close other off-gas lines such P-102, P-145 (FD-105A 1 and 2 bypass) P-130 and 131 sample lines before and after chromatograph.

Q3. What areas external to the reactor shielding may become a radiation hazard during this procedure?
(5)

A3.
a. Cover gas piping
b. Charcoal filters
c. Cleanup system
d. Shutdown pump area
e. Off-gas and fuel handling blower

Q4. a. If there is a significant fuel rupture, what instrument should first indicate this?

(2)

b. If the rupture was small, what instrument should first indicate this?

(2)

A4. a. FCF's
b. RRa-100 or iodine sample

Q5. What is the approximate capacity of one-half the F/D tank FA-305?

(2)

A5. 2,100 gallons

Q6. A possible cause of a fuel cladding failure could be a blocked fuel element passage. List three ways this may be avoided.

(3)

A6. a. Fuel testing and inspection
b. Core inspection prior to vessel closure
c. Outlined tool board
d. Pit inventory log
e. Cannot startup with a foreign object in the primary system

Q7. How are the following powered in each of these situations?

(6)

	Site AC Available	Site AC Failure Em. Gen. On	 Em. Gen. Off
RRa-100			
AGRM			
PC-106A and B			
RRa-105			
RRa-305			
RRa-306			

A7.

RRa-100	AC	Gen	12 Vdc
AGRM	AC	Gen	12 Vdc
PC-106A and B	AC	Gen	12 Vdc
RRa-105	AC	Gen	12 Vdc
RRa-305	AC	Gen	None
RRa-306	AC	Gen	None

Q8. What causes the 60% of scale reading during normal 60 MW operation on the FCF system?

(3)

A8. N^{16}

Q9. Who must be notified as to the status of the reactor during this procedure? (2)

A9. 1. Reactor Division Manager
2. HFBR Plant Manager
3. HFBR Group Leaders
4. S&EP

Q10. What are the shutdown limits for the following: (4)

a. Reactor Cover Gas

b. Exit Air Gas

c. Exit Air Particulate

d. Heavy Water Radioiodine Activity

A10. a. 1.5 R/hr on the reactor cover gas activity monitoring system

b. 10^5 cpm on exit air gas activity

c. 10 x background during 60 MW operation on exit air particulate monitor

d. 2.3×10^6 dis/min

Q11. What action would take if you suspected a fuel cladding failure on an element plate had occurred? (circle correct answer(s))

(3)

a. Notify Operations Group Leader and S&EP personnel

b. Shutdown the reactor and institute the Fuel Cladding Failure Procedure.

c. No action but close surveillance of the situation.

d. Shutdown primary pumps and depressurize reactor vessel.

A11. a.
b.

Q12. After a major fuel rupture, why is it necessary to shut off flow through the mixed beds of the purification system?

(4)

A12. Unless an adequate cooling flow is maintained through the mixed bed, the heat generated from the fission products collected in the resin bed can cause a breakdown of the resin and an explosion.

Q13. Describe what actions you would take during a massive fuel failure in which it was necessary to evacuate the operations level.

(4)

A13. Shutdown the reactor. Shut off the primary pumps. Close off He inlet controller PC-106B. Set He outlet controller to 250 psi. Evacuate the building. Notify Police Headquarters. Declare an alert.

Q14. Why are we concerned with F/D tank FA-305 level during an FCF?

(3)

A14. Cooling water from charcoal filters go to F side of FA-305.

Q15. The most likely time for a fuel cladding failure would be during a reactor startup. True or False?

(2)

A15. True

Q16. During a fuel cladding failure there are 2 major concerns that the emergency procedures are designed to accomplish. (circle correct answers).

(3)

a. Minimize extent of FCF.
b. Secure purification system.
c. Informing security of problem.
d. Contain the release within reactor vessel.

A16. a,d

Q17. Why is the pump seal vent system cold trap shutdown and bypassed?

(3)

A17. Pump seal leakage is contaminated with fission products at this time, and the cold trap would concentrate these contaminants in one spot.

Q18. What level of emergency should be declared on an FCF where FCF is reading greater than 75% scale? RRa-100 sample count is greater than 2.5×10^7 /m.

(3)

A18. Alert

COMPRESSED AIR FAILURE PROCEDURES

Q1. On failure of the Compressed Air System, what instrument can cause a reactor set-back on loss of its air supply?

(3)

A1. Loss of air to the shutter coolant flow transducer.

Q2. On failure of the Compressed Air System, what component in the Cover Gas System will open causing a reactor scram due to low cover gas pressure?

(3)

A2. The reactor depressurization valve.

Q3. Loss of compressed air to the following components will cause them to assume the following positions: (circle correct answer)

(3)

a. All four building air inlet valves will open.

b. The building exhaust blower discharge dampers will fail open.

c. The condensate drain valve on building air handling units IB-301 to Ib-308 will open.

d. Building exhaust bypass valves ABV-1 and ABV-2 will be held closed by using stored air from their individual reservoirs.

e. The pneumatic process instrumentation will indicate normal values.

A3. b.

Q4a. Describe what happens on loss of air to Break Tank Level Control Valve LC-306, and what systems are affected?

(4)

A4a. Valve will close shutting off the water supply to the canal cooler, the DW1 water supply to shutdown cooler and makeup to auxiliary water purification system.

Q4b. How can air be restored for operation of this valve and for how long?

A4b. A standby air bottle is available to provide up to ten hours of level control valve operation.

Q5. Describe what happens with loss of normal air supply to the building airlocks.

(3)

A5. All airlock control systems switch to their emergency air bottles.

Q6. During loss of compressed air to the following valves, state what position the valve remains in or goes to after the failure.

(5)

a. Secondary water holdup tank dump control valve DCV-1._____

b. Secondary water return valves WR1, WR2, and WR3. _____

c. Secondary water supply to valve WS3 to the shutdown cooler. _____

d. HC-102A and B primary pump suction valves. _____

e. HCV-101A and B primary system control valves. _____

A6. a. closed b. remain in position, c. operates on backup air supply
d. remain in position e. remain in position

Q7. When air is lost to the pumphouse air compressor receiver, what actions will occur? (5)

A7. Low pressure alarm will sound in control room. Cooling tower basin makeup control valves, conductivity control valve, secondary water temperature control valve, secondary water overpressure control valve will close. Low level sumps alarm may sound, and the compressed air supply to the water treatment house will fail.

Q8. If both normal building air compressors GB-301 A & B malfunction what can the operator do?

(2)

A8. Place backup air compressor GB-301C in service.

Q9. On loss of compressed air what position does WS-3 fail to and explain why.

(3)

A9. As is. Has an emergency air bottle on line that automatically comes on line on loss of compressed air.

Q10. If the loss of compressed air in reactor building or pump house was due to that systems air dryer failing, what would you do to return system to operation?

(4)

A10. Bypass the air dryer and secure and tag out air dryer.

Q11. What is the power supply to the reactor building run compressor and standby compressors?

(3)

A11. a. Run compressor - EMCC
b. Standby compressor - Equipment MCC #1

CORRECTIVE AND EMERGENCY PROCEDURES DURING FUEL DISCHARGING OPERATIONS

Q1. If the hoist fails while the element is still in view through the vessel scope, what steps are to be taken?

(3)

A1. a. Return element to core position.
b. Notify the Operations Group Leader before continuing discharge operations.

Q2. If the hoist fails after the element is out of view of the vessel scope but before an attempt to release it, what steps are taken?

(4)

A2. a. Return the element to the vessel.
b. Manually unloop air hose from reel and feed slack through shutters.
c. Lower element until it is just above the core as seen through the vessel scope.
d. Open shutters and return element to its core position.
e. Notify the Operations Group Leader before continuing discharging operations.

Q3. If the hoist fails after an attempt to release the fuel element is unsuccessful, what steps are taken?

(4)

A3. a. Maintain slide over canal chute.
b. Tension must be maintained on hose to keep element in air bonnet until there is enough hose free to lower element into the canal.
c. Lower hose a few inches with hand crank.
d. Unloop entire hose from reel, disconnect or cut hose from reel.
e. Straighten hose and feed through shutters until element is in canal.
f. Pull remaining air hose down into canal.
g. Notify Operations Group Leader before continuing discharging operations.

Q4. If the pickup mechanism fails to release during discharging operations, what steps are taken?

(3)

A4. a. Maintain slide over canal chute and lower element to canal.
b. Do not lower to canal with hand crank, lower by use of hoist motor or by unlooping.
c. Notify the Operations Group Leader before continuing discharging operations.

Q5. When is an element returned to the core? When is it discharged to the canal when there has been a loss of cooling air?

(3)

A5. a. To the core if the element is not in the air bonnet.
b. Immediately to the canal if element is in the air bonnet.

Q6. If an element becomes stuck during fuel discharging operations where it cannot be cooled, what two cautions must be followed?

(3)

A6. a. Keep the fuel blower operating.
b. Do not open the shutters.

Q7. What steps are followed by the reactor top personnel when an element becomes stuck without cooling during discharging operations?

(4)

A7. a. Attempt to free element with slide or lifting head. After five minutes, it the element is not free, the building must be evacuated as follows:
- Verify 400 gpm primary - 20-60 gpm domestic water to EA-103.
- Sound the evacuation alarm from the control room.
- Call police. Notify them of occurrence and declare an alert.
- The evacuation route should be announced via the north fork lock.

Q8. What do the canal members of the shift crew do after a loss of cooling accident to a fuel element and a building evacuation has been sounded?

(2)

A8. a. Leave building by the north fork lock.
b. Report to the lobby.
c. Verify lobby is safe and act as Traffic Coordinators unless LEC orders differently.
d. Contact the LEC for instructions.

Q9. Why is there a 26-hour waiting period after shutdown before fuel discharging can start?

(3)

A9. After 26 hours, the fuel element can hang indefinitely in the fuel bonnet or be cooled by immersion in the canal or vessel.

Q10. On the loss of AC power to Building 750, and the emergency generator is operating, what is the effect on the following?

(5)

a. Reactor pit H^3 monitor
b. Fuel handling blower
c. Fuel discharge slide
d. Exhaust blower GB-303B
e. Upper H^3 containment gamma monitor

A10. a. does not operate
b. does operate
c. does operate
d. does not operate
e. does operate

IN-VESSEL EXPERIMENTAL THIMBLE LEAK PROCEDURES

Q1. Briefly describe the symptoms of an in-vessel experimental facility thimble leak under the following conditions:

(4)

a. When the reactor vessel is pressurized.

b. When the reactor vessel is depressurized.

A1. a. Increased experimental facilities head tank level and pressure. Loss of reactor level and loss of pressure.

b. A decrease in head tank level and an increase in reactor vessel level.

Q2. A primary-to-secondary experimental facilities cooler leak will also cause a rise in head tank level and pressure, but without affecting vessel level. True or False?

(2)

A2. True

Q3. Briefly describe what action you would take in the event of an in-vessel experimental facility leak.

(4)

A3. Shutdown the reactor. Shutdown both experimental facilities cooling water pumps. Isolate each thimble. Notify RD Manager and/or Operations Group Leader.

Q4. Describe procedure to determine which facility thimble is leaking.

(3)

A4. a. Obtain group leader authorization.
b. Establish a differential pressure between EFCS head tank and reactor vessel.
c. Open each thimble return valve and reclose until one of the valve openings causes differential pressure to equalize.

APPENDIX J

LECTURE CRITIQUE

LECTURE CRITIQUE

EMERGENCY PROCEDURES

SUMMARY OF SIX RESPONSES

1. Was the instruction interesting?

   5 Yes 1 okay

2. Were the problem solving sessions helpful in performing your job?

   5 yes 1 stated that he didn't believe a course of a few hours once every two years has a lasting effect on his performance. We need to keep a review schedule on our own.

3. Would you like to see more of this done during emergency procedure training?

   6 yes

4. How could the situations be improved?

   More realistic walk throughs. Sometimes we cover a lot of ground in a short time. Teamwork was good, helpful by actually performing some of these with plant. Also a better attempt of doing them in the actual time frame events would happen. We could make the training more realistic by running drills in the plant. Put time lines on problem. Put more pressure on participants.

5. Were sufficient problem exercises included and were they appropriate?

   6 yes

6. Was the review of unusual occurrence reports appropriate? Was it helpful?

   5 yes 1 no

Review of past experience is helpful especially long ago. Was enlightening. I thought it was a waste of time to try and list the top ten or worst UOR's that occurred at the HFBR. I didn't see the relevance in this exercise.

7. Did you receive sufficient feedback during the problem solving sessions?

   5 yes 1 adequate

8. Did the tests measure your performance on the stated objectives.

   6 yes

9. Did you receive sufficient feedback on your test results.

   6 yes

APPENDIX K

SUPERVISORS EXAMINATION

PRIVATE

HFBR
Supervisor
QRP-EP
W

Approved by R. Reyes

High Flux Beam Reactor

QUARTERLY RETRAINING PROGRAM:

EMERGENCY PROCEDURES

SUPERVISOR EXAMINATION

(97 points)

Administered to _____ Date 12/21/87

Administered by R. Reyes Date 12/21/87

Corrected by R. Reyes Score 92.7%

Reviewed with Examinee by R. Reyes Date 12/31/87

Additional Corrective Action Required NONE

Corrective Action Completed _____ Date _____

INSTRUCTION SHEET FOR WRITTEN EXAMINATION

This written examination may contain a variety of question types. These may include essay, multiple choice, matching and true or false. Each question is accompanied by a credit point value which is in parenthesis at the right margin. The credit point value of each section and the total for the exam appear on the cover sheet.

The purpose of an essay question is to determine the depth of your understanding of the subject. In some cases a single word or short sentence may properly answer the question, however, in other cases a paragraph or more may be necessary to fully explain your answer. Credit can only be given for what you have written on the page. The person grading this exam cannot read between the lines or ask you additional questions to draw out a full answer. When you have completed your response, reread it to be sure it includes all of what you wanted to say.

The space provided to answer each question should not be taken as an indicator of the size of the answer. If the space provided is insufficient for your answer, use the back of that page. If still more space is needed, additional paper will be provided which should be attached to the back of the exam. All answers not written in the space provided under the question must be identified by section and question number.

BASIC EMERGENCY SHUTDOWN PROCEDURE

Q1. Assuming a primary-secondary leak has occurred in EA-101A, indicate the following: (5)

a. What instrumentation will indicate the leak and what indication will it show?

Increase in RRa 301a Sec. H_2O Gamma monitor reading ✓
Increase in RRa 307 Sec H_2O H^3 monitor reading ✓
Increase in Beckmann Tritium sample if taken manually ✓
Possible decrease in Vessel Pressure PRa101, etc. ✓
Possible decrease in Vessel Level LRa101, etc. ✓

b. What valving and equipment operational changes must be made?

Shutdown Reactor + BESP
Shut off Primary Pumps A+B ✓
Shut off Pony Motor A ✓
Shut off Secondary H_2O pumps ✓
Close HCV-101A, HC102A, HCV301A, WR-1, DCV-1 ✓
Depressurize

Q2. If a primary cooler tube ruptured during 60 MW operation, briefly describe the action you would take. (4)

Shutdown Reactor
Perform BESP
Perform All Steps mentioned above in part (Q1)
Perform Additional steps in Secondary Water Isolation Emerg Procedure.

Restore liquid level to vessel
and establish shutdown cooling

-.5

152

Q3. List the possible methods by which light water can enter the primary system. (3)

- Primary HX Leak ✓
- Light water line rupture in pit with vessel open
- Contaminated Fuel Handling Tools ✓
- Intentionally during Poison Water or Primary Rupture Procedure ✓

Q4. If a D_2O leak was detected in the reactor pit area, what actions would you take? (4)

✓

- Shutdown Reactor + Depressurize Vessel
- BESP
- Attempt to determine degree & location of leak using Level, Pressure instruments
- Take Frit Sample
- Move location of Pit sample line to determine if upper or lower pit is location of Leak

COMPRESSED AIR FAILURE PROCEDURES

Q5. Loss of compressed air to the following components will cause them to assume the following positions: (circle correct answer) (3)

a. All four building air inlet valves will open. ✓

b. The building exhaust blower discharge dampers will fail open.

c. The condensate drain valve on building air handling units IB-301 to Ib-308 will open.

d. Building exhaust bypass valves ABV-1 and ABV-2 will be held closed by using stored air from their individual reservoirs.

e. The pneumatic process instrumentation will indicate normal values.

Q6a. Describe what happens on loss of air to Break Tank Level Control Valve LC-306, and what systems are affected? (4)

Valve Fails Closed

~~Emerg Bottle must be valved on manually~~ ✓

Water supplied to: Canal Cooler (Secondary H_2O) - BG201
DW-1 to SD HX
Charcoal Filters for cooling

Q6b. How can air be restored for operation of this valve and for how long?

Emerg Air Bottle must be valved on manually ✓
10 hrs.

Q7. When air is lost to the pumphouse air compressor receiver, what actions will occur? (5)

- Pump House Air Press Low Alarm received in Control Room ✓
- Pump Sump Level low Alarm " " " " ✓
- Air to Water Treatment Home lost ✓
- PCV-1, CCV-1, TCV-1, MCV-1+2 fail closed ✓

FLOW REVERSAL PROCEDURES

Q8. Under what conditions will flow reversal occur? (3)

Primary Pumps A & B off
Shutdown pumps A & B off
Pony motors unable to maintain flow (i.e. loose head)
} loss of all forced cool...

Q9. Why is flow reversal (natural circulation) necessary under these conditions? (3)

To cool the core due to loss of forced flow
Prevent fuel damage due to overheating

Q10. What must be done before adding condensate to the reactor vessel if the primary-secondary differential pressure limit has been violated in the cooler used to condense steam? (3)

Analyze water sample to ensure it is within purity limits.

Q11. The time required for all the water in the reactor vessel to reach the boiling point following initiation of natural circulation cooling depends on three factors. What are those three factors? (3)

Rx power level before shutdown ✓

Time from shutdown that forced cooling was lost ✓

Length of time Rx was operating ✓

Vessel level ✓

Q12. Describe how to determine that the steam generated in the reactor core is being condensed in the shutdown cooler and flowing by gravity to the storage tank. (4) -2

Increase in FA101 Level Noise Gauge reading

Reactor vessel pressure stays close to atmospheric

Q13. During set-up for flow reversal, using the shutdown cooler, the steam pressure starts to rise above the 14 psig. Describe what actions you would take. (4) ✓

Open P102 to maintain pressure below 14 psig

CORRECTIVE AND EMERGENCY PROCEDURES DURING FUEL DISCHARGING OPERATIONS

Q14. If the hoist fails after the element is out of view of the vessel scope but before an attempt to release it, what steps are taken? (4)

Unloop hose manually & feed thru shutter (don't open)

Return element to core position.

Q15. When is an element returned to the core, and When is it discharged to the canal when there has been a loss of cooling air? (3)

If no attempt has been made to release it to canal.

and if chute remains over vessel.

to the core if element is not in air bonnet immediately to the canal if element is in the air bonnet

Q16. What steps are followed by the reactor top personnel when an element becomes stuck without cooling during discharging operations? (4)

Attempt to free Element using chute

If can't be freed in 5 minutes:

- Push Bldg Evacuation Button
- Ensure 400 GPM on SD pump & Secondary H_2O to S/D HX
- Evacuate
- Inform Police
- Declare Alert

IN-VESSEL EXPERIMENTAL THIMBLE LEAK PROCEDURES

Q17. Briefly describe the symptoms of an in-vessel experimental facility thimble leak under the following conditions: (4)

a. When the reactor vessel is pressurized.

Increase in Exper Head Tank Press above Secondary Side Press. ✓

" " " " " Level

Decrease in Vessel Level

Flow variation in thimble possible

b. When the reactor vessel is depressurized.

Decrease in Exper. Head Tank level ✓

Increase in Vessel Level

Q18. Briefly describe what action you would take in the event of an in-vessel experimental facility leak. (4)

Shutdown Rx

BESP ✓

Isolate Thimbles

Shut off Exper Pumps

Close Exper. Exp. Tank

PROCEDURE IN THE EVENT OF AN IN-CORE FUEL CLADDING FAILURE

Q19. What instruments and/or procedures may be indicative of a fuel cladding failure? (5)

FCF monitors ✓

Primary Water Iodine sample ✓

RRa 100 ✓

RRa 305 ✓

RRa 306 ✓

RRa 105 ✓

Cell Area & monitors ✓

Q20. A possible cause of a fuel cladding failure could be a blocked fuel element passage. List three ways this may be avoided. (3)

Inspection of ex-elements before charging ✓

Pit Tool Board Inventory ✓

Core Top & Vessel inspection ✓

Q21. What causes the 60% of scale reading during normal 60 MW operation on the FCF system? (3)

N^{-16} background activity in primary water ✓

6 & 7 Mev Gammas

Q22. Describe what actions you would take during a massive fuel failure in which it was necessary to evacuate the operations level. (4)

-1

Shutdown Rx ✓

BESP ✓

Bldg Evacuation Procedure ✓

FCF Procedure

maintain Vessel Pressurized ✓

Core Cooled ✓

declare an alert

Be more descriptive

ie, shut down reactor, evacuate building, call on alert, close helium inlet cont close " out cont remove resin bed

Q23a. Where is the Emergency Operations Facility located? (5)

Bldg 50 ✓

Q23b. Who staffs this facility? Name five functions.

Assistant Director of Lab ✓
LES ✓
DOE personnel ✓
S&EP rep. ✓
Reactor Div. Rep. ✓

Q24. Match the following as they relate to the BNL Emergency Response Plan. (5)

a. Describes procedures to cope with emergencies.

b. Houses management personnel who direct BNL operations during an emergency.

c. Describes procedures to cope with emergencies at the HFBR.

d. Loss of control of radioactive material.

e. Is not found in the BNL Emergency Response Plan.

b Emergency Operations Facility ✓
e HFBR Building Evacuation Procedure ✓
a Emergency Plan ✓
c HFBR Local Emergency Plan ✓
d Radiological Emergency ✓

Q25. Define the following terms and what action to take during each condition. (5)

a. Personnel Emergency

Injury to one or more people requiring emergency assistance

Call 2222 ✓ -.5

b. Unusual Event

Out of Limits condition reached or events that may lead to possible HFBR failure or danger

Notify: Group Leaders, Div Mgr, DOE

Ex: > 2.3 × 10⁶ dpm Iodine sample

c. Alert

Events underway that will likely lead to major failure of HFBR

ex: Full scale ECF readings sustained

EOS manned, Tech. Support Center manned. Call 2222 calla alert

d. Site Emergency

Events underway requiring evacuation of BNL site

Major failure at HFBR likely w/ danger to site personnel

ex: Fission Products in Containment Call 2222 callalert

e. General Emergency

Possible core melting

Loss of 2 out of 3 of Fission Product Boundaries Call 2222 callalert

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